Special Report 1038
July 2002

Malheur Experiment Station Annual Report 2001

OREGON STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION

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

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Idaho-Eastern Oregon Onion Committee
Idaho Mint Commission
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PHOSPHORUS CONTENT OF THE MALHEUR RIVER

Clinton C. Shock and Andrew Nishihara
Malheur Experiment Station, Oregon State University
Kathy Pratt, Malheur Watershed Council, and
Ron Jones, Malheur County Soil and Water Conservation District
Ontario, OR, 2001

Summary

The main stem and tributaries of the Malheur River were sampled for total phosphorus monthly for 4 1/2 years from mid-1997 through 2001. Samples were analyzed by the U.S. Bureau of Reclamation in Boise, Idaho. Phosphorus (P) content in the river averaged 0.208 mg/L at Drewsey and 0.086 mg/L above Beulah Reservoir, the highest spots sampled on the Middle Fork and North Fork of the Malheur River respectively. Maximum levels at these sites were 0.43 mg/L and 0.18 mg/L respectively. At the outlet of Beulah Reservoir on the North Fork of the Malheur River, total phosphorus averaged 0.145 mg/L and reached 0.34 mg/L. Background of phosphorus in the Malheur River above row crop agriculture averaged 0.175 mg/L and reached a maximum of 0.48 mg/L during spring runoff.

These high levels of phosphorus extending relatively far up into the Malheur River watershed suggest geological sources of phosphorus in the watershed. The possible effect of Warmsprings Reservoir in removing phosphorus from the Middle Fork, little or no effect on river total P from pasture irrigation and rangeland management over an extended reach of the river, and phosphorus enrichment in the lower reach of the Malheur River near Vale and Ontario are discussed.

Materials and Methods

A surface water monitoring program has been conducted by the Malheur Watershed Council and the Malheur County Soil and Water Conservation District since mid-1997. Grab samples were taken once per month at 31 monitoring sites throughout the Malheur Basin. The U.S. Bureau of Reclamation Water Quality Lab in Boise analyzed the samples for six parameters: chlorophyll-a, conductivity, *E.coli*, nitrate, total phosphorus (P), and turbidity. The presence of *E.coli* was a concern in the Willow Creek area so sampling was increased to five times per month for *E.coli* on nine of the sites. Only the total phosphorus values from the Malheur River sites are reported here.

In addition, flow measurements at the U.S. Geological Survey gauge stations were recorded at the Namorf gauge station, Nevada Diversion, and at the 36th Street Bridge on the Malheur River. Additional flow measurements were taken on the Middle Fork and the North Fork at the county bridges at Juntura and the South Fork near Riverside above its confluence with the Middle Fork.

Data from each of the Malheur River sites (Map 1) was subjected to descriptive statistics to determine the mean, standard deviation, minimum, and maximum total P over the 4 1/2 years of sampling. Data was graphed individually for each site over the course of each year of the last 4 years to examine visually the relationship of season and the irrigation season to total P content in the water.

Results and Discussion

Importance of the Current Results and Unanswered Questions

Total P levels were relatively high at all locations sampled (Table 1). While background levels for total P are often in the range of 0.02 mg/L in streams descending from western U.S. mountains, the total P levels in the Malheur River were considerably higher. These results are consistent with the survey conducted in 1978 and 1979 in cooperation with the EPA and Oregon Department of Environmental Quality, which showed relatively high total P throughout the Malheur Basin (Malheur County Court 1981).

Results from the 1978-1979 Malheur County survey show that more orthophosphate was transported by the Middle Malheur River plus the North Fork of the Malheur River at Juntura, than by the main stem of the Malheur River east of Vale (Figure 9, Malheur County Court, 1981).

Uplands

The highest elevation sampled on the Middle Fork of the Malheur River averaged 0.208 mg/L total P at Drewsey (Fig. 1). The maximum observed total P at this site was 0.43 mg/L. Above Drewsey there is irrigated meadow, rangeland, and forest. The highest total P at Drewsey occurred before and after the irrigation season, consistent with either the flush of spring runoff or the dwindling flow in late summer and early autumn.

The Malheur Watershed Council's highest elevation sample site on the North Fork above Beulah Reservoir, averaged 0.086 mg/L total P above Beulah Reservoir (Fig. 4). The maximum observed total P at this site was 0.18 mg/L. The water that is caught and stored in Beulah Reservoir comes out of forest and rangeland with relatively little anthropogenic influence. The analyses suggest that the natural background level of phosphorus is high. Further sampling and investigation will provide information regarding the geological makeup of this area.

Warmsprings Reservoir

At the Middle Fork both below Drewsey and below Warmsprings Reservoir, total P averaged 0.178 mg/L, maximum total P reached 0.40 mg/L, and the standard deviation was 0.065 mg/L (Fig. 2). The reservoir might have some effect on reducing total P in the Middle Fork through sedimentation, but the magnitude of the sedimentation effect could only be known through measures of P inputs and outputs to the reservoir over a number of years, which would required more intensive water sampling and flow measurements. Such sampling and measurements are not viewed as a priority.

After joining with the South Fork, the river had no additional P enrichment through the ranch land to Juntura, averaging 0.155 mg/L total P, with a maximum of 0.42 mg/L, and standard deviation of 0.063 mg/L (Fig. 3). Below Juntura, the river is immediately joined by the North Fork.

Beulah Reservoir

The second sampling site down the North Fork was located directly below the Beulah Reservoir. Total P averaged a surprising 0.145 mg/L total P with a maximum of 0.34 mg/L, where just a few miles above the river contained only 0.086 mg/L total P with a maximum of 0.18 mg/L. The consistent sharp increase in P suggests P enrichment in the vicinity of the reservoir.

Probable sources of P enrichment in this stretch of the North Fork are lake bottom sediments of various formations (Cummings 2000, Bowen 1956, Gray 1956). Sedimentary deposits underlie and surround the North Fork from about half way from Juntura to Beulah Reservoir and continue well beyond the reservoir to the north, east, and west (Cummings 2000, Wood 1976). These sedimentary lake bottom formations could also be enriching the Middle Fork of the Malheur River with P. Sedimentary rocks have not been collected for P analyses by the current project.

At Juntura, the North Fork averaged 0.170 mg/L with an observed maximum of 0.35 mg/L total P (Figure 6), The two highest measurements occurred during winter runoff. Phosphorus levels were no higher during the pasture irrigation season than other times of the year.

Ranch Land Irrigation

The Malheur River winds past various areas with pasture irrigation starting at Drewsey, past Juntura and Namorf, and eventually past Harper, and there was no apparent P enrichment over this river stretch (Table 1, Figs. 7, 8, and 9). While total P averaged 0.178 mg/L below the outlet of Warmsprings Reservoir on the Middle Fork and 0.170 mg/L at the outlet of the North Fork at Juntura, the total P in the Malheur River averaged 0.175 mg/L at Harper, in the range that would be expected for no additional P loading. In this stretch of the Malheur River, the highest observed total P at Namorf (0.48 mg/L) and Juntura (0.39 mg/L) occurred in association with early spring flows from snow melt or rain on snow (Figs. 7 and 9).

Row Crop Farming, Communities, and Lower Malheur Basin Geology

In the lower reaches of the Malheur River, total P increased (Table 1, Figs. 10-14). The most probable causes for the increase are geologic contributions, intensive agricultural irrigation return flows, and other human influences. By the 36th Street Bridge in Ontario, total P averaged 0.357 mg/L while the minimum total P level was 0.21 mg/L and the maximum observed was 0.81 mg/L. The highest levels of total P in the row crop stretch of the river occurred during winter or early spring flow prior to the irrigation season. The high peaks in P outside of the irrigation season suggest that the occasional delivery of very high levels of total P to the Snake River are unavoidable in the P-rich Malheur River valley.

Geological contributions of P to the lower Malheur River basin are poorly understood. The Malheur River flows through Little Valley before reaching the confluence of Bully Creek and the city of Vale. Based on 13 widely diverse samples Brooks (1991) described the rocks in the Little Valley quadrangle as containing 0.42 to 1.66 percent phosphate. The single basalt sample contained 0.53 percent phosphate. Andesite ranged from 0.42 to 0.44 percent phosphate. Basaltic andesite contained 0.68 to 0.81 percent phosphate. Limestone contained 0.52 to 1.66 percent phosphate. It is unknown how far this level of P extends in rocks and sedimentary deposits of the lower Malheur River basin, or the rate that these rocks release P to water at present or in the past.

Conclusions

The phosphorus monitoring of the Malheur River in the current project demonstrated that the water in the Malheur River has high total P throughout its length, consistent with earlier studies (Malheur County Court 1981). The current study also discovered that the water becomes enriched at the height of Beulah Reservoir on the North Fork, a site with relatively little human P inputs or disturbances. The enrichment of the North Fork in the vicinity of Beulah and of the Middle Fork above Drewsey both suggest a geological source or sources of P, perhaps from ancient lake deposits that also occur at those locations in the landscape. The P containing geological formations need study to determine their influence on the P content in the Malheur River.

Further river water contact with ranching and pasture irrigation from Drewsey to Juntura to Namorf to Harper had no net effect on total P in the Malheur River water. Subsequent to the river stretch through ranching areas, the river became further enriched in total P. At Little Valley the river passes through geological deposits known to contain 0.42 to 1.66 percent phosphate. Starting at Little Valley, the river passes through row crop farming and the farming intensifies in the vicinity of Vale and Ontario.

With the high levels of total P at the headwaters, current monitoring demonstrated that the background of phosphorus in the Malheur River above row crop agriculture averaged 0.17 mg/L and reached maximums above 0.40 mg/L during winter and spring runoff. Changing agricultural practices cannot reduce P levels in the river below these background levels.

The Malheur Watershed Council as well as other agencies can use this information to better understand the relative geologic and anthropogenic causes of total P in the Malheur River. Given that the background level of P is responsible for much of the P content in the basin, continued monitoring can still show the positive effects of projects and changes in farming practices on the phosphorus levels in the Malheur River.

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Acknowledgments

The monitoring reported here has been conducted by the Malheur-Owyhee Watershed Council, now known as the Malheur Watershed Council, through generous support by the Oregon Watershed Enhancement Board. The most recent grant was OWEB No. 99-240. Sampling was conducted by Ed Gheen, Kerby Winters, and Larry Powers. The Watershed Council has been led during the monitoring by Ed Gheen, Jonathan Matthews, and Kathy Pratt. The monitoring program has been successful through the voluntary contribution of time by members of the Malheur Watershed Council's data subcommittee. The Data Committee consisted of Connie Bateman, Ray Dunten, Ray Huff, Jim Nakano, DeVon Knutson, Vince Gaona, Ed Gheen, Dick Haines, Ron Jacobs, Bob Moore, Frank Robinson, Ray Archuleta, Ray Perkins, Clinton Shock, and Kathy Pratt.

Map 1. Location of Malheur River sites.

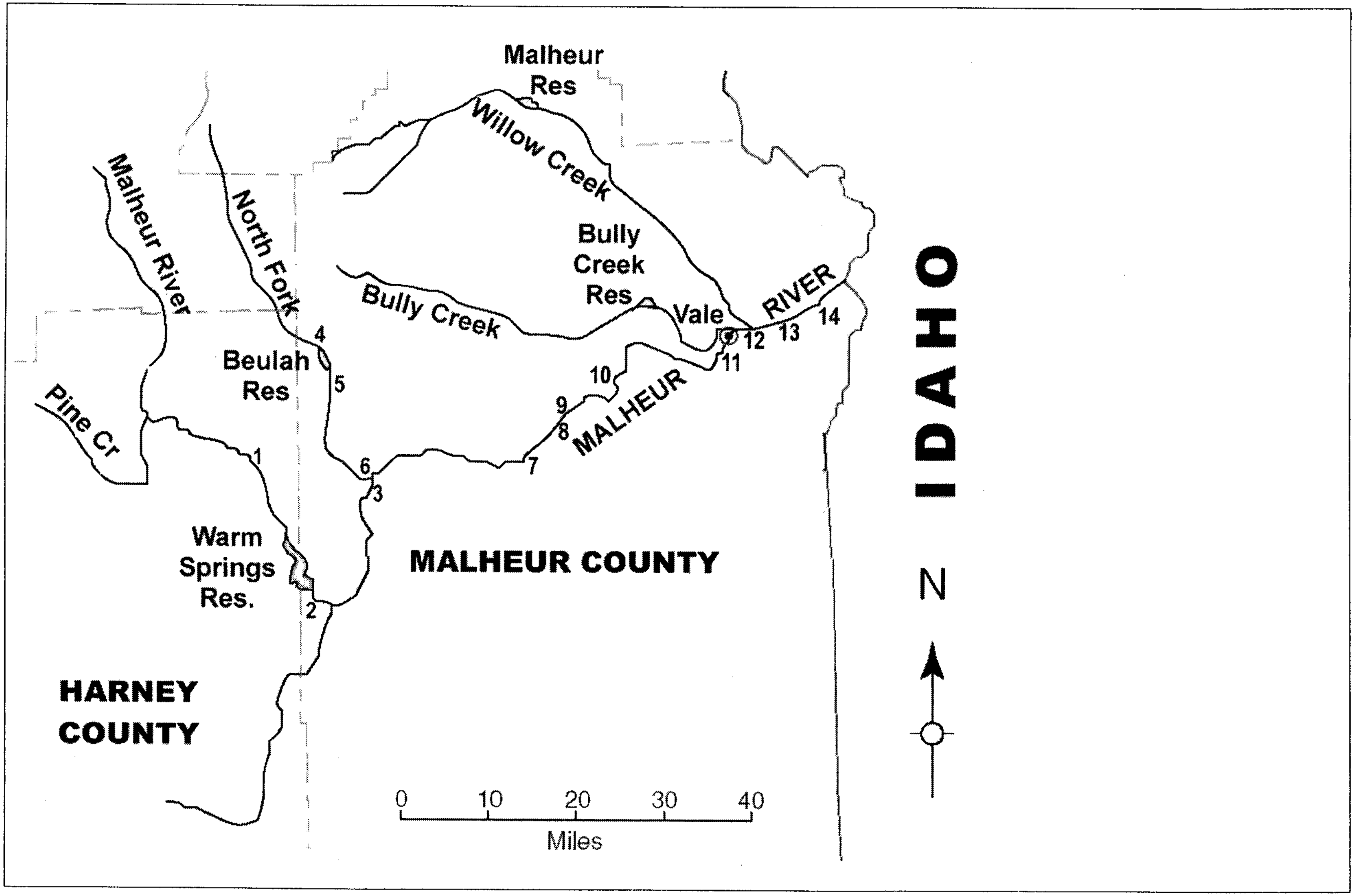

Table 1. Total P in the main stem and the middle and north forks of the Malheur River based on monthly sampling from mid 1997 through 2001. Malheur Watershed Council, Ontario, OR, 2001.

Location		Total phosphorus			
Figure Site	Place name	Mean	Standard deviation	Minimum	Maximum
		mg/L			
Middle Fork					
1 MAL108	Drewsey	0.208	0.096	0.082	0.43
2 MAL111	Riverside	0.178	0.065	0.08	0.4
3 MAL002	Juntura	0.155	0.063	0.056	0.42
North Fork					
4 MAL113	Above Buleah	0.086	0.028	0.05	0.18
5 MAL112	Below Buleah	0.145	0.054	0.072	0.34
6 MAL158	Juntura	0.17	0.059	0.02	0.35
Main Stem of the Malheur River					
7 MAL104	Namorf	0.167	0.066	0.074	0.48
8 MAL194	Harper	0.158	0.041	0.094	0.23
9 MAL146	Harper	0.175	0.059	0.03	0.39
10 MAL103	Little Valley	0.212	0.071	0.02	0.47
11 MAL144	SW of Vale	0.271	0.081	0.06	0.58
12 MAL011	E of Vale	0.324	0.08	0.18	0.6
13 MAL142	Butte Dr., Ontario	0.344	0.102	0.05	0.74
14 MAL140	36th St., Ontario	0.357	0.103	0.21	0.81

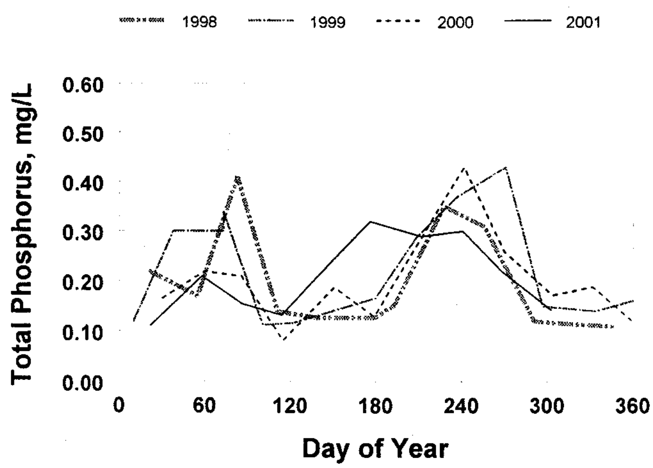

Figure 1. Total phosphorus in the Middle Fork of the Malheur River at site MAL108, 4 miles SW of Drewsey upstream of the Highway 20 bridge.

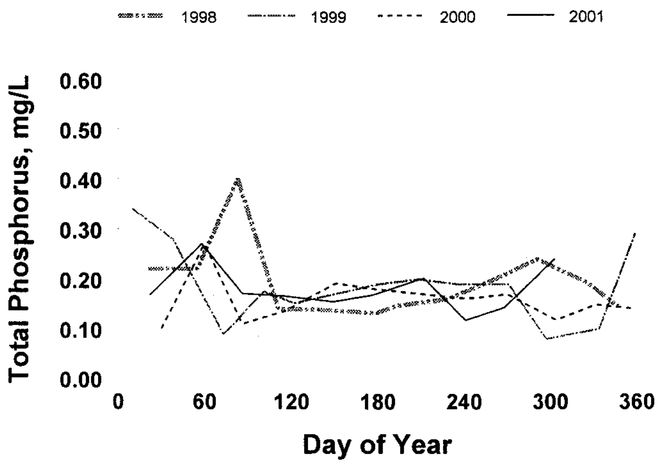

Figure 2. Total phosphorus in the Middle Fork of the Malheur River at site MAL111, 1 mile below Warm Springs Dam, upstream from the steel suspension bridge over the river.

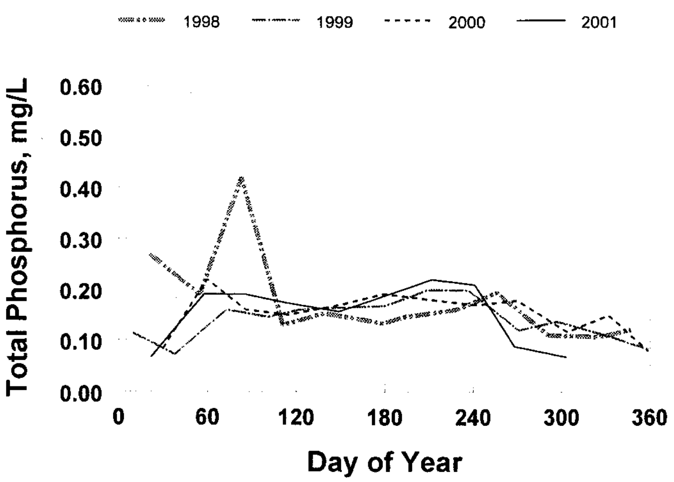

Figure 3. Total phosphorus in the Malheur River at site MAL002, at Juntura, 150 feet upstream from the county bridge near the Bureau of Land Management guard station.

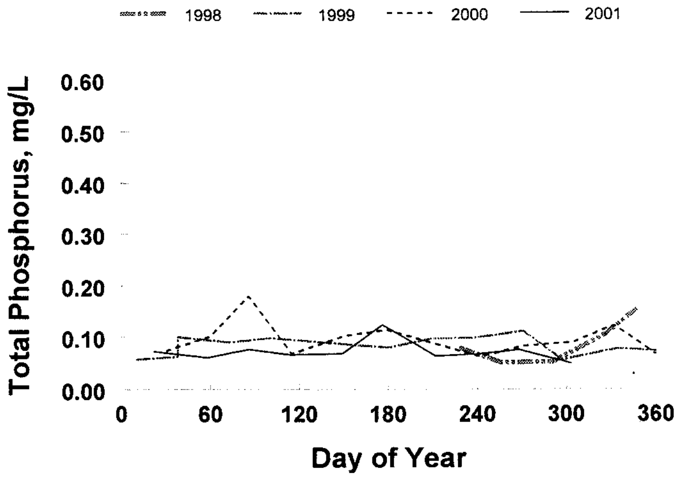

Figure 4. Total phosphorus in the North Fork of the Malheur River at site MAL113, above Buleah Reservoir, 300 feet downstream of the U.S. Geological Survey gauge station (lake level permitting), if not, then at gauge station.

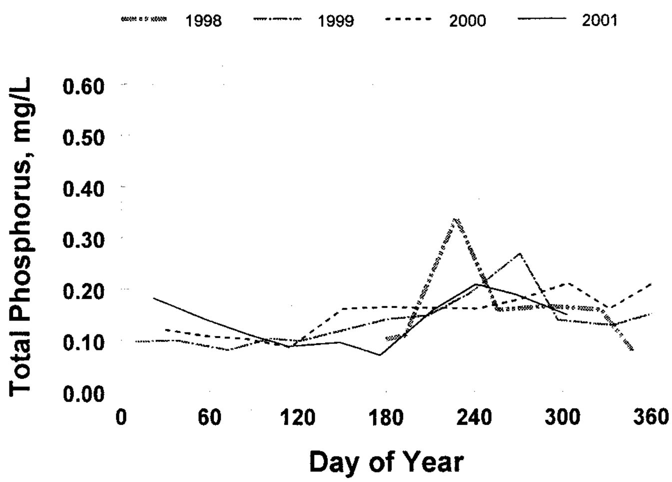

Figure 5. Total phosphorus in the North Fork of the Malheur River at site MAL112 below Beulah Reservoir, directly below the dam.

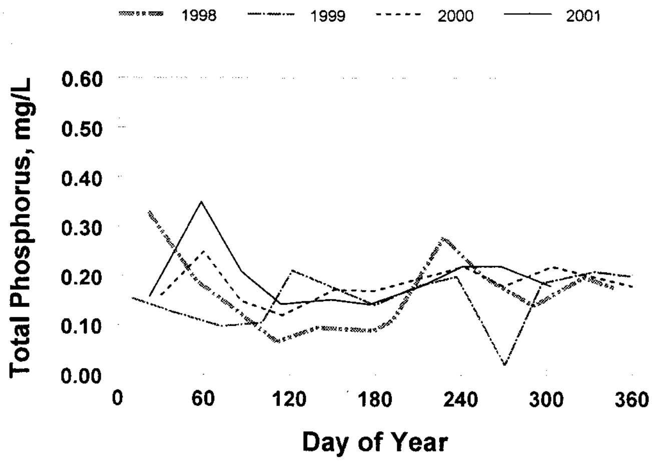

Figure 6. Total phosphorus in the North Fork of the Malheur River at site MAL158, near Juntura, at the bridge site ½ mile northwest of Juntura on Beulah Road.

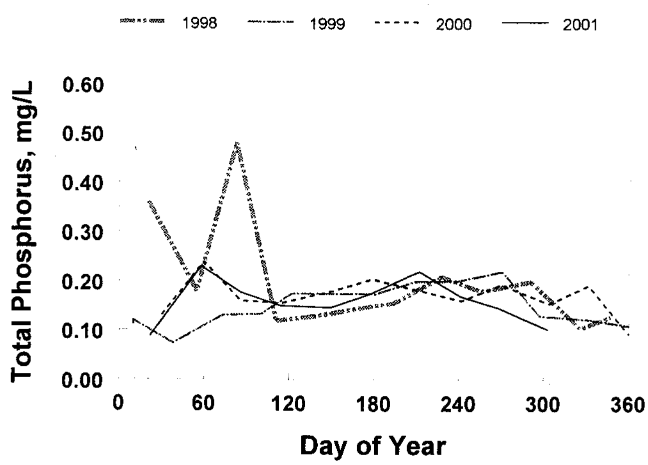

Figure. 7. Total phosphorus in the Malheur River at site MAL104, at the gauge station under railroad bridge, next to Highway 20 at Namorf.

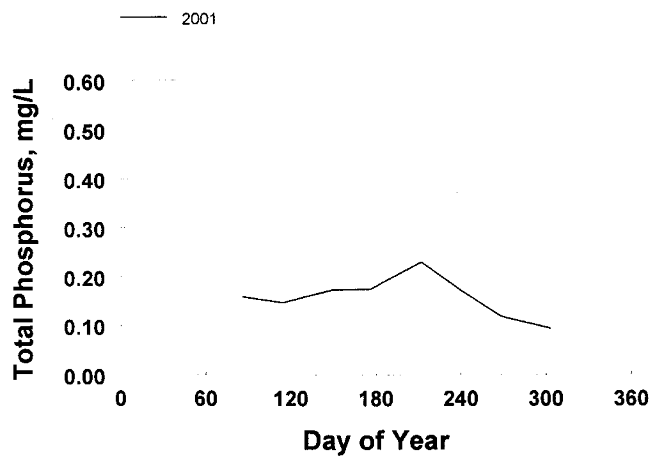

Figure 8. Total phosphorus in the Malheur River at site MAL194, above the Harper bridge.

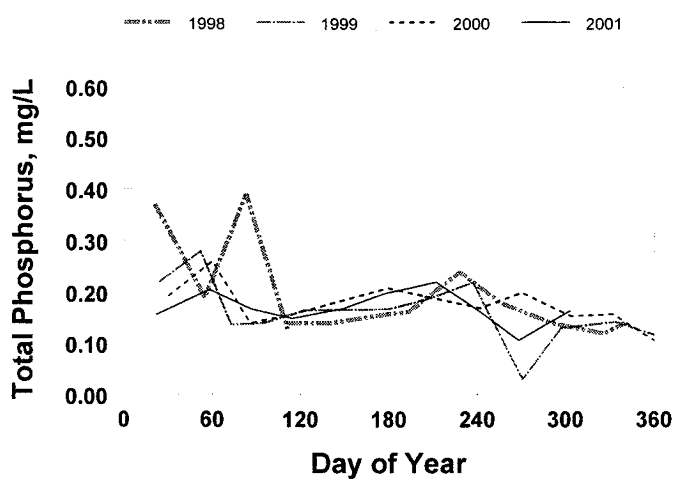

Figure 9. Total phosphorus in the Malheur River at site MAL146 near Harper, ¼ mile north of Highway 20 at bridge near Harper junction.

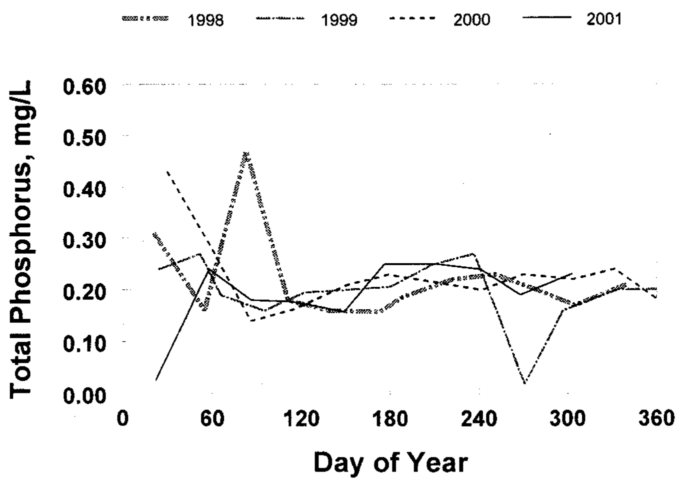

Figure 10. Total phosphorus in the Malheur River at site MAL103, near Little Valley 11/2 miles northwest of Highway 20, at Old Highway Bridge.

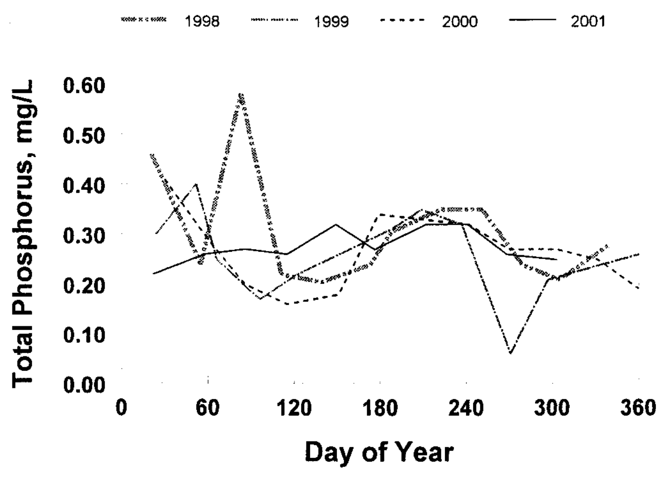

Figure 11. Total phosphorus in the Malheur River at site MAL144, southeast of the Vale airport.

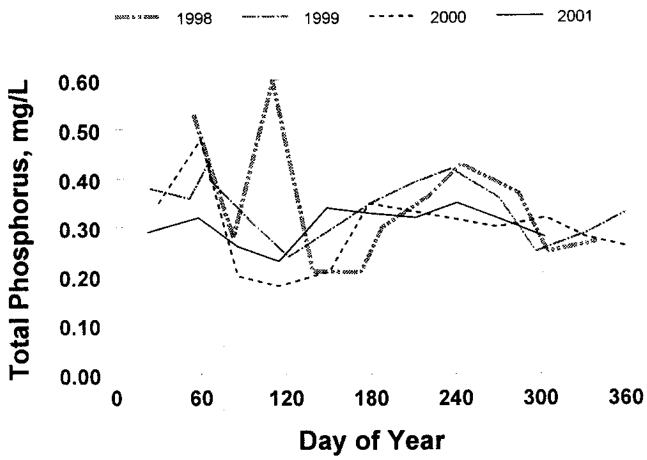

Figure 12. Total phosphorus in the Malheur River at site MAL011, between the Nevada Diversion Dam and the Vale mushroom farm.

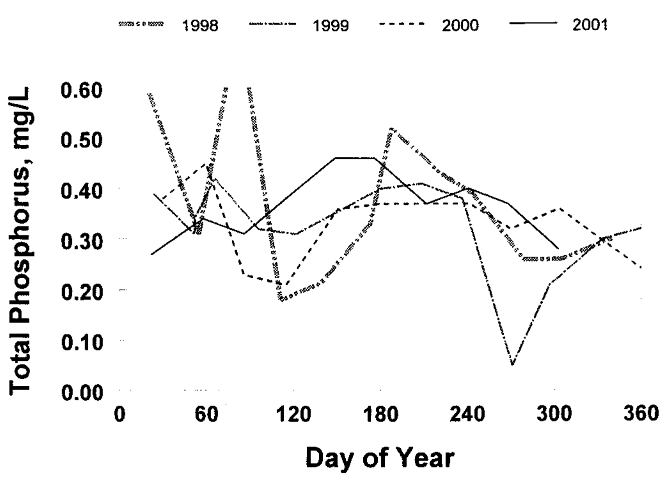

Figure 13. Total phosphorus in the Malheur River at site MAL142, at 11/2 miles north of Highway 20 on Butte Drive at the bridge.

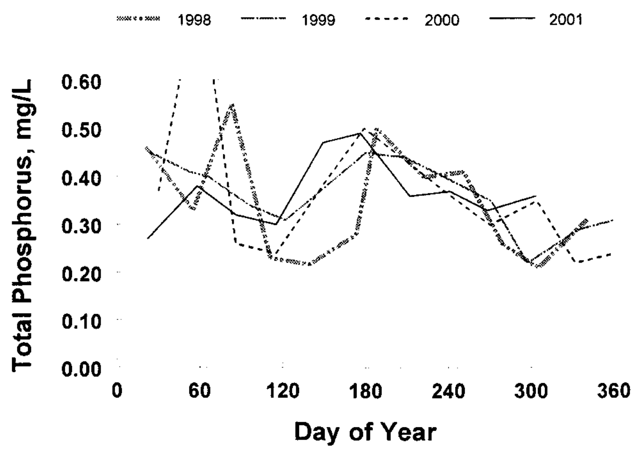

Figure 14. Total phosphorus in the Malheur River at site MAL140, near Ontario at the 36th Street Bridge, which is located ½ mile south of Foothill Drive on 36th Street.

2001 WEATHER REPORT

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Introduction

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

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 is transmitted via satellite to the Boise computer every 4 hours and is used to calculate daily Malheur County crop water-use estimates. The AgriMet database can be accessed via computer modem or through the internet at www.pn.usbr.gov/agrimet and is linked to the Malheur Experiment Station web page at www.cropinfo.net.

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.

Methods

The ground under and around the weather stations had been bare, but was covered with turfgrass on October 17, 1997. The grass is irrigated with subsurface drip irrigation. The weather data is recorded each day at 8:00 a.m.

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 peak Et is calculated for an alfalfa crop that is kept uncut during the season. Alfalfa mean Et is calculated for an alfalfa crop assuming a 15 percent reduction to account for cuttings. Alfalfa peak Et would be the same as reference Et when the alfalfa reaches full cover. 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.

2001 Weather

The total precipitation for 2001 was lower than the 10-year and 55-year averages and was the lowest in the last 10 years (Table 1).

The months of May and August had a higher number of growing degree days (50° to 86°F) than the 15-year average (Table 2). The total number of growing degree days in 2001 was close to the 15-year average (Table 2). The total number of growing degree days in 2001 was closer to the 10-year average when compared to the highest (1994) and lowest (1993) years since 1990 for growing degree days (Fig. 1). May had substantially more degree days in the above optimal range (86° to 104°F) than the previous 10-year average (Table 3). The total number of degree days in the above optimal range in 2001 was close to the previous 10-year average.

The months of January and February had total wind runs 53 and 22 percent lower, respectively, than the 10-year average (Table 4). The months of November and December had total wind runs 33 and 40 percent higher, respectively, than the 10-year average. November 29, 2001 had the highest wind run since October 1990. Total pan-evaporation for May was 16 percent higher than the 10-year average and 31 percent higher than the 53-year average (Table 5). Total pan-evaporation for 2001 was close to the 10-year and 53-year averages.

Total Et for all crops in 2001 was slightly higher than the 9-year mean (Table 6).

Mean monthly air temperatures were close to the 10-year and 53-year average (Table 7).

From March through October the mean monthly maximum and minimum 4-inch soil temperatures were lower than the 10-year and 34-year average (Table 8). The difference in soil temperature between 2001 and the mean is probably influenced by the installation of turf around the weather station in October of 1997. The soil remained warmer in winter and cooler in spring and summer. The last spring frost (≤32°F) occurred on April 29, 1 day later than the 25-year average date of April 28; the first fall frost occurred on October 10, 6 days later than normal (Table 9).

The weather in 2001 did not exceed any record weather events recorded over the 57-year history for the Malheur Experiment Station (Table 10). The highest temperature for the year was 103°F on July 5 (Table 6). The lowest temperature for the year was 10°F on January 27 and February 2. Total precipitation was 7.78 inches for the year, the lowest since 1991 and 28 and 25 percent lower than the 10-year station average and the 55-year station average (Table 1). Total pan-evaporation for April through October was 58.3 inches, close to the 10-year average and slightly higher than the 53-year average (Table 4). Total snowfall for 2001 was 15.5 inches, slightly lower than the 10-year and 58-year average (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, 1991-2001.

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
10-yr avg	1.64	1.08	0.90	1.05	1.40	0.84	0.47	0.14	0.30	0.81	1.12	1.28	10.80
55-yr avg	1.37	0.99	0.95	0.81	1.07	0.79	0.26	0.40	0.50	0.71	1.17	1.32	10.32

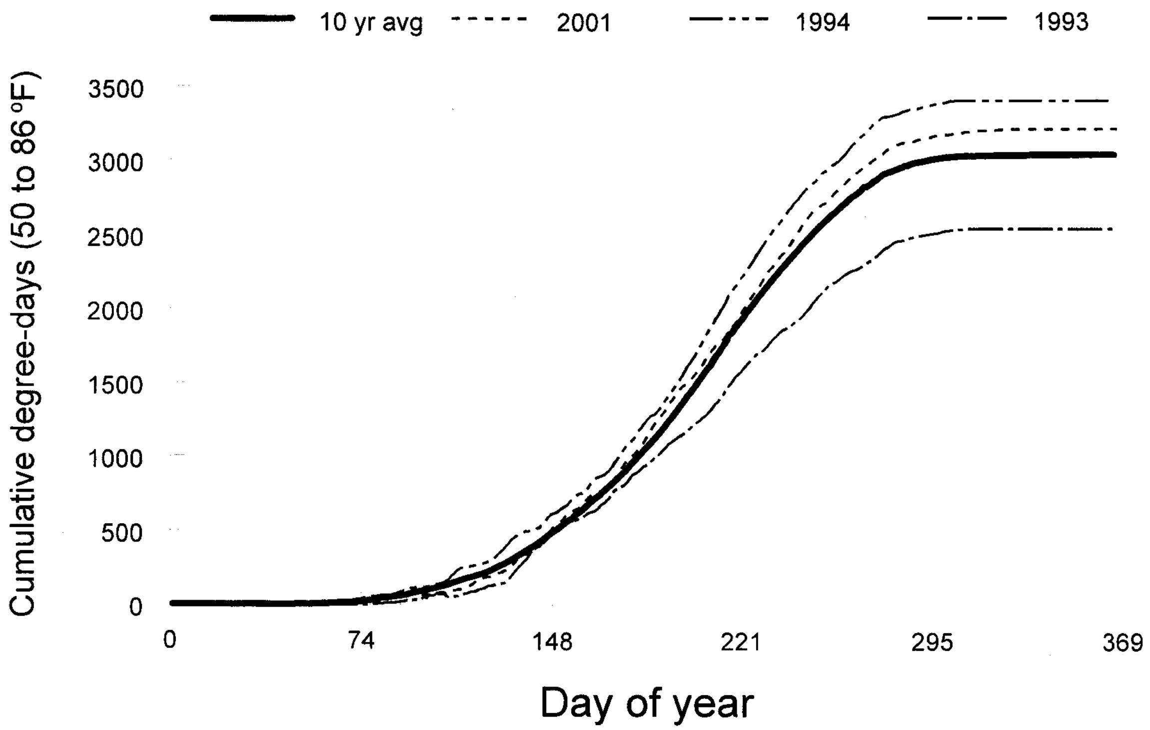

Figure 1. Cumulative growing degree days (50-86°F) over time, Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 2. Monthly total growing degree days (50-86°F), Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2001.

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
15 year avg	0	7	54	155	319	508	715	681	432	169	12	1	3,053

Table 3. Monthly total degree days (86 -104°F), Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2001.

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
10-yr avg	0	1	7	40	37	6	0	91

Table 4. Daily wind-run totals and monthly totals, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Daily	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	------------------------ miles ------------------------											
Max.	89	237	227	155	169	163	93	114	164	118	405	268
Min.	2	9	16	37	26	27	32	19	21	21	24	2
Average	24	50	68	73	83	72	62	53	53	52	71	76
Annual total	------------------------ miles ------------------------											
2001	747	1,387	2,121	2,203	2,587	2,147	1,924	1,635	1,586	1,625	2,120	2,357
10-yr average	1,576	1,780	2,378	2,481	2,340	1,988	1,807	1,704	1,639	1,798	1,595	1,682
53-yr average				2,144	1,924	1,560	1,473	1,325	1,257	1,283		

Table 5. Pan-evaporation totals, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Totals	April	May	Jun	Jul	Aug	Sep	Oct	Total
Daily	------------------------ inches ------------------------							
Mean	0.18	0.32	0.33	0.35	0.34	0.24	0.14	
Max.	0.30	0.50	0.49	0.50	0.50	0.42	0.32	
Min.	0.03	0.08	0.14	0.18	0.22	0.09	0.03	
Annual	------------------------ inches ------------------------							
2001	5.45	10.03	10.03	10.88	10.48	7.15	4.28	58.30
10-yr avg	6.04	8.64	9.37	11.46	10.80	7.54	4.40	58.25
53-yr avg	5.59	7.64	8.86	11.12	9.60	6.27	3.20	52.28

Table 6. Total Et (acre-inches/acre), Malheur Experiment Station, Oregon State University, Ontario, OR, 1992-2001.

Year	Reference Et	Alfalfa (peak)	Alfalfa (mean)	Spring grain	Sugar beet	Onion	Potato - Shepody	Potato	Field corn
1992	50.6	51.8	44.5	28.6	34.8	30.6	32.6	27.6	29.2
1993	44.1	42.5	36.7	22.4	29.5	24.2	22.4	22.9	24.5
1994	50.0	47.4	40.7	23.2	34.5	29.6	22.5	28.0	28.6
1995	44.8	43.4	37.2	23.1	29.0	25.6	24.7	24.1	24.3
1996	47.7	46.4	39.8	23.7	33.0	28.0	25.1	27.1	26.7
1997	49.5	48.3	41.6	25.8	33.4	28.0	24.7	28.3	26.2
1998	49.2	47.4	40.6	24.6	32.5	28.2	25.1	27.1	27.9
1999	53.1	51.3	44.0	25.7	33.8	29.5	26.7	28.0	28.6
2000	54.8	53.2	45.6	25.8	38.3	32.5	27.3	30.4	29.7
2001	52.8	51.2	43.8	27.3	34.8	30.1	27.8	28.0	28.0
9-year avg	49.3	48.0	41.2	24.8	33.2	28.5	25.7	27.1	27.3

Table 7. Monthly air temperature, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

	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																							
Max.	40	32	49	32	72	44	83	50	97	66	97	63	103	72	102	71	93	58	85	52	64	45	45	33
Min.	22	10	30	10	43	22	42	24	60	34	63	42	73	48	79	48	70	38	53	28	35	22	23	17
2001 avg	33	22	40	25	58	34	61	37	77	47	81	52	90	59	93	59	83	49	66	39	52	32	36	25
10-yr avg	37	24	45	27	56	32	64	37	74	46	80	51	90	57	91	54	81	46	66	36	47	28	37	23
58-yr avg	35	20	43	25	55	31	64	37	74	45	82	52	91	57	90	55	80	46	66	36	48	28	37	22

Table 8. Monthly soil temperature at 4-inch depth, Malheur Experiment Station, Oregon State University, Ontario, OR 2001.

	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																							
Max.	34	33	38	36	50	46	60	56	70	65	74	70	79	72	76	72	73	68	62	57	52	50	38	36
Min.	31	30	30	28	36	35	45	41	52	49	60	54	69	64	71	63	61	57	47	46	37	31	32	29
2001 mean	32	31	33	31	44	41	50	46	61	56	68	62	74	68	74	68	67	62	53	51	45	43	35	33
10-yr mean	34	33	39	36	49	42	58	48	69	58	76	65	83	71	83	72	74	65	60	53	44	41	36	35
34-yr mean	33	32	38	34	50	41	61	48	73	58	81	66	89	74	87	73	76	64	61	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, 1990-2001.

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	April 29	Oct 10	164
1976-2000 Avg	April 28	October 4	159

Table 10. Record weather events at the Malheur Experiment Station, Oregon State University, Ontario, OR from 1943 through 2001.

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 inches	Oct 25, 1970
Highest air temperature	108°F	Aug 4, 1961
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, 1991-2001.

1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	10-yr avg	58-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	16.8	18.6

THIRD YEAR RESULTS OF THE 1999 TO 2003 ALFALFA FORAGE VARIETY TRIAL

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Introduction

With increasing dairy herds in Oregon and Idaho and increasing exports of alfalfa cubes, compressed bales, and pellets to nations across the Pacific, a marketing opportunity has developed for premium quality hay. Quality hay can be obtained by cutting alfalfa early, when buds are fully formed but before the first flowers open. Total yield will be lower than it could be with later cuttings. When there is strong demand for premium 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 are being compared to 2 public check varieties for production of high quality hay. The purpose of this trial is to identify alfalfa varieties that remain productive when cut early for high quality hay. The trial is being grown on marginal soil with sprinkler irrigation, characteristic of soils and irrigation practices available for alfalfa hay production.

Methods

The trial was established in September 1998, on Nyssa silt loam that has not been deep plowed. Details of this trial's establishment are in a previous annual report (Eldredge, et al., 2000) or on the internet at www.cropinfo.net/annualreports/1999/alf99a2est.htm.

Plots were 20 ft long by 5 ft wide, separated at their ends by 3-foot alleys, with each variety replicated five times in a randomized complete block design. Fall regrowth was cut with a flail mower on December 19, 2000, to reduce soil cover to improve herbicide spray penetration and effectiveness. Soil cover during winter can also promote rodent colonization of the alfalfa stand. A tank mix of Gramoxone at 0.23 lb ai/acre plus Sencor at 0.46 lb ai/acre was applied on March 15 to control winter annual weeds and to provide residual soil active herbicide. On August 10, annual grasses and broadleaf weeds were controlled with an application of Pursuit at 2 oz/acre plus Select at 10 oz/acre.

The alfalfa was harvested on May 22, June 26, August 3, and September 24, 2001. The first cutting was slightly late, as some plants were in bloom. Second cutting was at bud stage. Third cutting was also at bud stage, and fourth cutting was 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 alfalfa moisture content at each cutting. Yield was reported based on alfalfa hay at 88 percent dry matter.

Forage quality samples of approximately 20 stems per plot were taken at second cutting at bud stage. The second cutting forage quality samples were dried, ground to pass a 1-mm screen, sub-sampled, 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 analyze percent crude protein, percent acid detergent fiber (ADF), and percent neutral detergent fiber (NDF). Relative feed value (RFV) was calculated by the formula:

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

Quality standards based on RFV are Prime, RFV higher than 151; No. 1, RFV 151 to 125; No. 2, RFV 124 to 103; No. 3, RFV 102 to 87; No. 4, RFV 86 to 75; and No. 5, RFV less than 75 (Undersander et al. 1991). A higher RFV means less grain or feed concentrate is required to formulate the dairy ration.

Results and Discussion

The average total hay yield was 5.68 ton/acre (Table 1). There were no significant differences in hay yield between varieties in the first, second, or third cuttings. The fourth cutting was delayed into September because regrowth was too slow after the third cutting. In the fourth cutting, 'W-L 325HQ' produced 1.35 ton/acre, which was significantly more hay than the lowest five varieties in the fourth cutting.

The crude protein, which averaged 23.3 percent in the second cutting, ranged from 24.1 percent for 'Multi-5301' to 22.2 percent for 'Lahontan'. Crude protein for 'Multi-5301' was significantly higher than the lowest four crude protein values of varieties in the second cutting. ADF averaged 28.9 percent. NDF averaged 39.4 percent. All varieties except 'Gold Plus' and 'Lahontan' produced Prime quality hay, with RFV higher than 151, in the second cutting.

The 3-year hay yield averaged 5.75 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 of the 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 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. Oregon State University Agricultural Experiment Station Special Report 1015:12-15.

Undersander, D., N. Martin, D. Cosgrove, K. Kelling, M. Schmitt, R. Becker, C. Grau, and J. Doll. 1991. Alfalfa management guide. ASA-CSSA-SSSA, Madison, WI.

Table 1. Alfalfa variety hay yields and second cutting crude protein*, ADF*, NDF*, and relative feed value for 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

Variety	Cutting date 5/22	6/26	8/3	9/24	2001 total	Crude protein	ADF†	NDF‡	Relative feed value
	ton/acre§					% of DW¶			RFV
W-L 325 HQ	1.38	1.69	1.94	1.35	6.35	23.6	28.1	38.5	163
Surpass	1.60	1.59	1.84	1.25	6.28	23.4	29.0	39.5	156
Tango	1.66	1.60	1.64	1.29	6.19	23.5	29.6	40.2	153
Rambo	1.62	1.47	1.58	1.13	5.81	23.5	28.4	38.9	160
ZX9453	1.41	1.49	1.66	1.19	5.76	23.3	29.2	39.8	155
Emperor	1.42	1.53	1.67	1.13	5.76	23.4	28.8	39.5	157
DK 142	1.36	1.39	1.59	1.32	5.66	23.6	28.6	39.1	159
Gold Plus	1.22	1.41	1.80	1.23	5.66	22.6	30.2	40.7	150
Archer II	1.45	1.44	1.63	1.11	5.63	22.8	29.7	39.8	154
Wrangler	1.29	1.44	1.69	1.11	5.53	23.2	28.8	39.3	158
Plumas	1.33	1.38	1.53	1.18	5.42	23.5	28.8	39.6	157
G9722	1.31	1.43	1.63	1.00	5.37	23.0	28.4	38.5	162
Lahontan	1.19	1.43	1.69	0.93	5.25	22.2	30.0	40.4	151
Multi-5301	1.07	1.24	1.45	1.03	4.79	24.1	27.7	38.4	163
Mean	1.38	1.47	1.67	1.16	5.68	23.3	28.9	39.4	157
LSD(0.05)	NS††	NS	NS	0.24	NS	1.0	NS	NS	NS

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

Table 2. Forage yield of alfalfa varieties over three production years. Malheur Experiment Station, Oregon State University, Ontario, OR 2001.

Variety	1999	2000	2001	3-year Total	3-year Average
	ton/acre*				
Rambo	4.62	7.52	5.81	17.95	5.98
Surpass	4.22	7.41	6.28	17.91	5.97
Emperor	4.55	7.60	5.76	17.91	5.97
ZX9453	4.42	7.61	5.76	17.79	5.93
Archer II	4.57	7.54	5.63	17.74	5.91
Tango	3.83	7.68	6.19	17.70	5.90
G9722	4.36	7.82	5.37	17.55	5.85
W-L 325 HQ	3.68	7.43	6.35	17.46	5.82
DK 142	4.25	7.32	5.66	17.23	5.74
Plumas	3.75	7.71	5.42	16.88	5.63
Gold Plus	3.85	7.29	5.66	16.80	5.60
Wrangler	4.37	6.86	5.53	16.76	5.59
Multi-5301	3.99	7.52	4.79	16.30	5.43
Lahontan	4.20	6.17	5.25	15.62	5.21
Mean	4.19	7.39	5.68	17.26	5.75
LSD (0.05)	NS	0.67	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 2001.

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	Forage Genetics	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	Forage Genetics	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	-	-	-

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

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

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Summary

Two alfalfa varieties ('Tango' and 'Accord') were grown for seed using subsurface drip irrigation with four evapotranspiration (Et_c) replacement levels: 20, 40, 60, and 80 percent of the accumulated deficit. After flower bud formation, the alfalfa was irrigated every 3 to 4 days and the corresponding Et_c deficit applied. In the 2001 season, 'Tango' seed yield was optimized at 39 percent of Et_c replacement or 13.2 inches of applied water and 'Accord' seed yield was optimized at 45 percent of Et_c replacement or 13.8 inches of applied water.

Purpose

Work at the Malheur Experiment Station in the 1980's demonstrated that water stress was associated with high alfalfa seed yields (Shock et al. 1989). Achieving uniform water stress across the length of the field with furrow irrigation is problematic because water application is not uniform. In areas of the field where more water soaks into the soil, alfalfa remains vegetative, while alfalfa in dry areas can become excessively dry. Subsurface drip irrigation applies water more uniformly and allows 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

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, T-Systems Int., Kennewick, WA) buried at 12-inch depth between two alfalfa rows. The drip tape was buried on alternating inter-row spaces. 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 inches/hour. In 2000 the field was irrigated uniformly the entire season. The seed was harvested with a commercial combine.

Alfalfa Irrigation

In 2001, the alfalfa was not irrigated until bud formation. The alfalfa was flailed on May 3 to delay flowering. Approximately 2 acre-inch were applied on May 23 and another 2 acre-inch on June 1. The small irrigation differences between treatments up to June 1 were unintentional (Fig. 1). After June 1, 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, Fig. 2). 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 23.

Each plot was eight alfalfa rows wide, 480 ft long, and had 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 evapotranspiration 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, Idaho) adjacent to the field. The Et_c was estimated and recorded from dormancy break on March 1 until the final irrigation on August 21. 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 field middle 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 6, 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 28. On September 5, 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.

Lygus Bug Monitoring and Control

Lygus bugs were monitored twice weekly by taking three 180° sweeps with an insect net in each of six locations throughout the field. 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).

Results and Discussion

Differential Irrigation

The total Et_c from dormancy break to the start of flowering (March 1 to June 2) was 11.7 inches, substantially higher than the approximately 4 acre-inch applied uniformly to all plots (Fig. 1). After the start of flowering, the treatments were clearly differentiated in terms of cumulative amount of water applied over time (Fig. 2). The total amount of water applied was 19.5, 14.8, 9.8, and 5.0 acre-inch per acre for treatments 1 through 4, respectively. The total Et_c from the start of flowering until the last irrigation was 26.2 acre-inch. The total Et_c for the season was 37.9 inch.

Soil moisture was closely related to the irrigation treatments (Fig. 3). Soil moisture content at 12-inch depth for treatments 1, 2, and 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 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. 4). Soil moisture content at 20-inch depth for treatments 1, 2, and 3 was similar during and between irrigations. Soil moisture content at 20-inch depth for treatment 4 did not responded to irrigations.

Alfalfa Seed Yields

Lygus bug insecticide applications were not effective in maintaining the population below the economic threshold (four lygus bugs per 180° sweep) during the season (Fig. 5). Lygus bug populations were very damaging to the driest treatments, which began blooming first. This was because lygus bug populations happened to be high early.

Alfalfa seed yield increased with increasing Et_c replacement (Fig. 6) and applied water (Fig. 7), reached an optimum, and then decreased. 'Tango' seed yield was optimized at 39 percent of Et_c replacement or 13.2 inches of applied water and 'Accord' seed yield was optimized at 45 percent of Et_c replacement or 13.8 inches of applied water. Whole plant, stem, and leaf dry matter yields increased with increasing water applied (Fig. 8). Seed pod dry matter yield increased with increasing applied water, reached a maximum, and then decreased. 'Tango' seed pod yield was optimized at 38 percent of Et_c replacement or 11.9 inches of applied water and 'Accord' seed yield was optimized at 45 percent of Et_c replacement or 15.6 inches of applied water (Fig. 8 and 9).

References

Shock, C.C., W.P. Stephen, V. Cairo, T.D. Stieber, and M. Saunders. 1989. Irrigation, insect population, and disease management for alfalfa seed production. Oregon State University Agricultural Experiment Station, Special Report 844:16-21.

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

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

Date	Application mode	Product	Rate lb ai/acre
June 6	Ground	Capture	0.099
		Cygon	0.25
July 2	Aerial	Metasystox-R	0.5
July 12	Aerial	Metasystox-R	0.5
July 22	Aerial	Capture	0.032
August 1	Aerial	Metasystox-R	0.5
August 11	Aerial	Capture	0.032

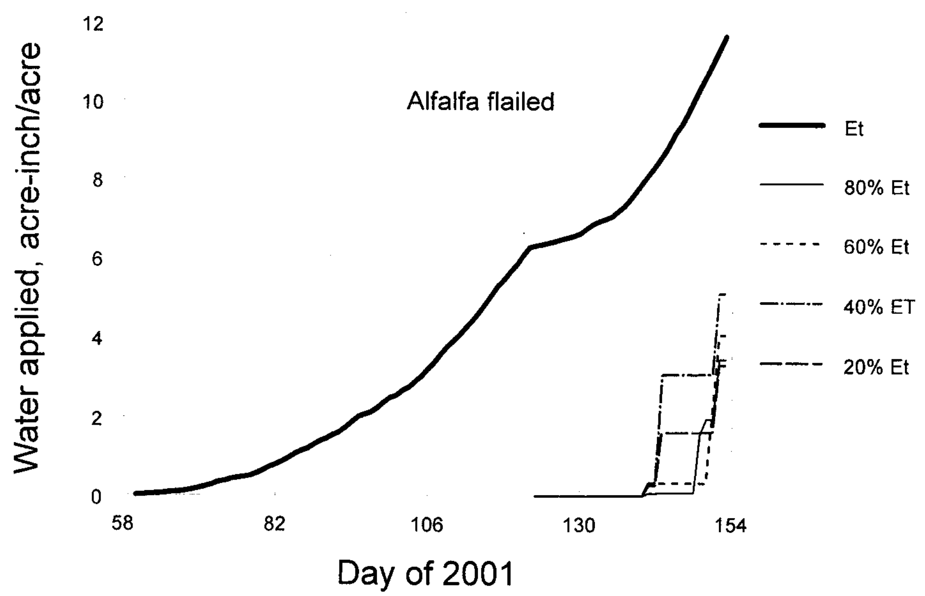


Figure 1. Cumulative water applied from dormancy break to flowering compared to Et for alfalfa seed. The small irrigation differences between treatments up to June 1 were unintentional. Malheur Experiment Station, Oregon State University, Ontario, OR.

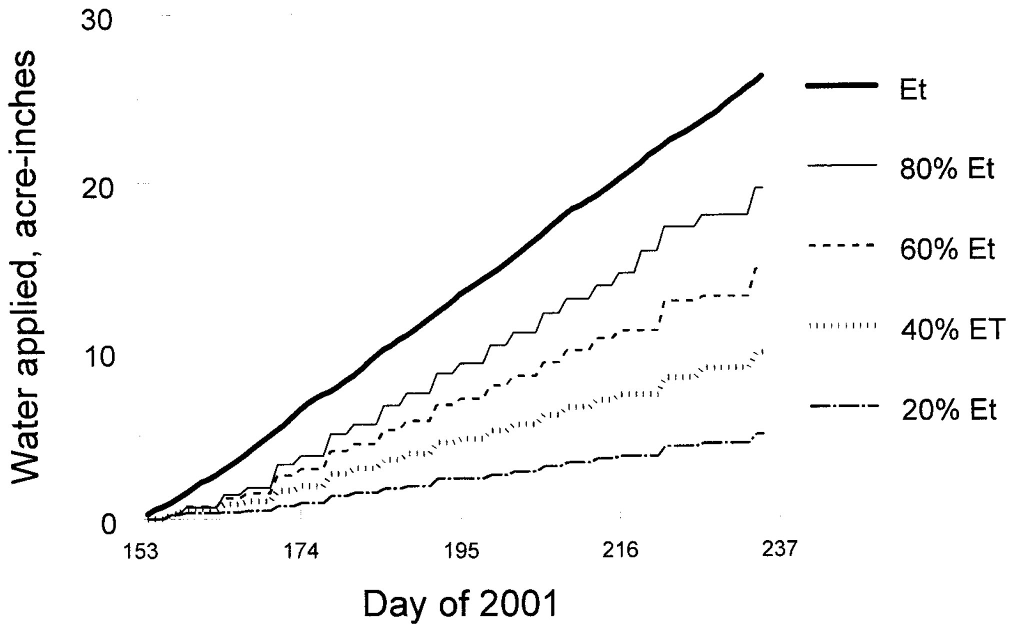


Figure 2. Cumulative water applied after flowering compared to Et for alfalfa seed submitted to four drip-irrigation treatments. Malheur Experiment Station, Oregon State University, Ontario, OR.

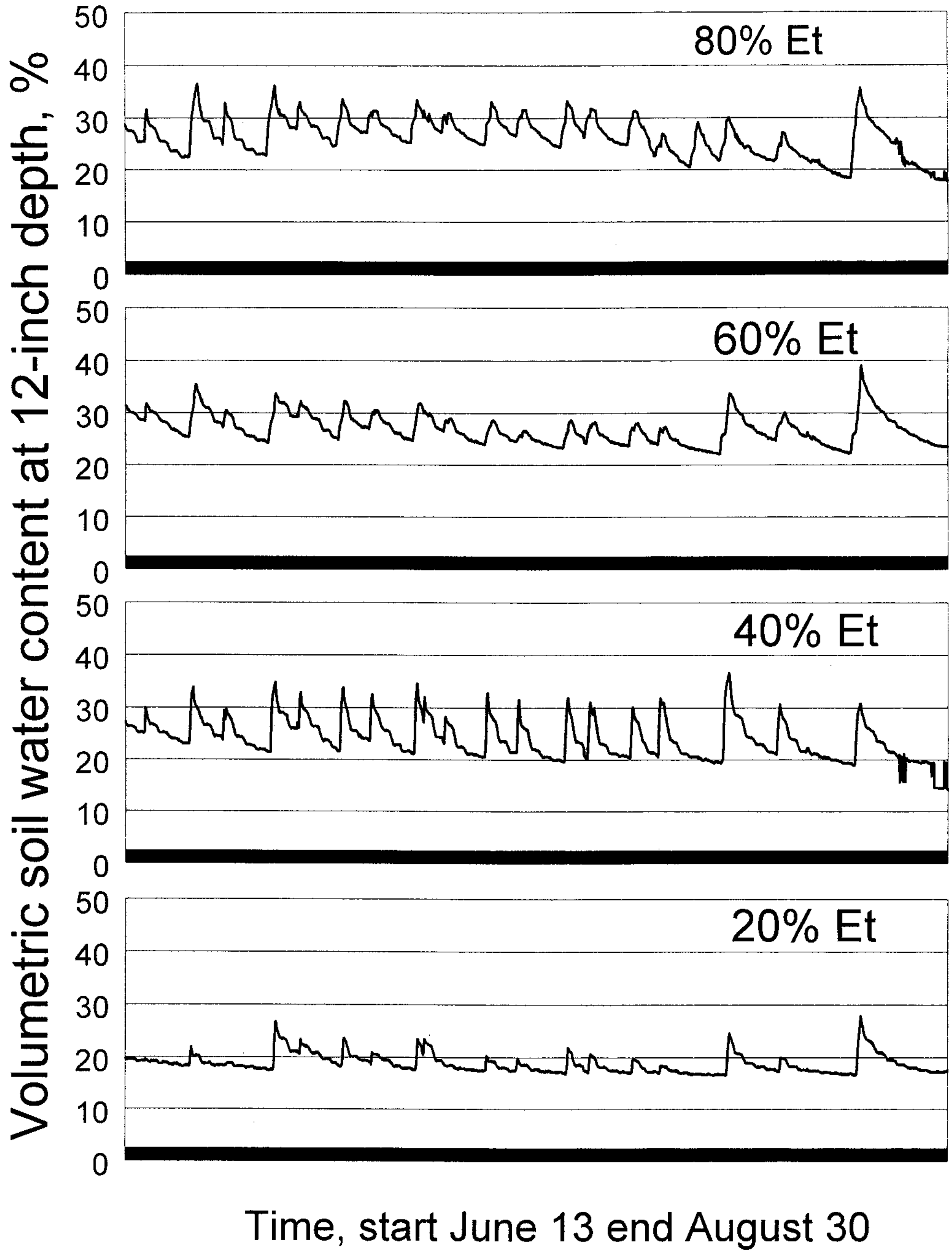


Figure 3. Soil moisture at 12-inch depth in response to irrigation treatments in a drip-irrigated alfalfa seed field. Malheur Experiment Station, Oregon State University, Ontario, OR.

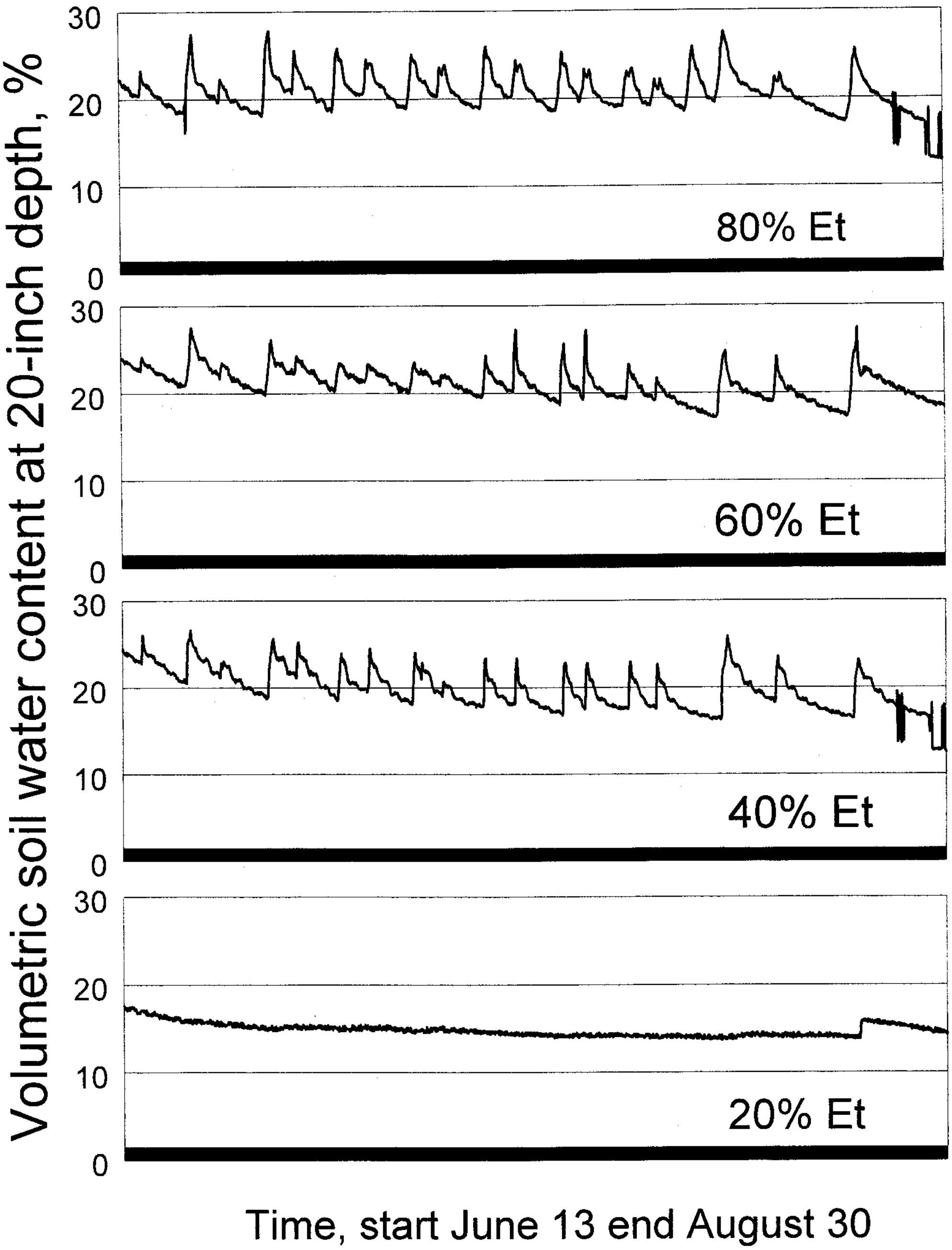


Figure 4. Soil moisture at 20-inch depth in response to irrigation treatment in a drip-irrigated alfalfa seed field. Malheur Experiment Station, Oregon State University, Ontario, OR.

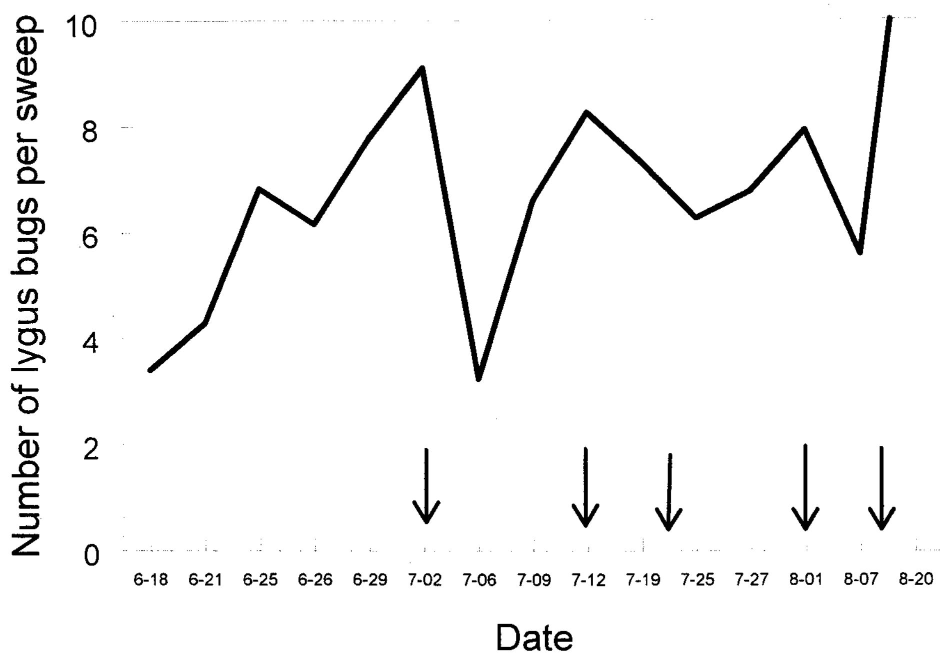
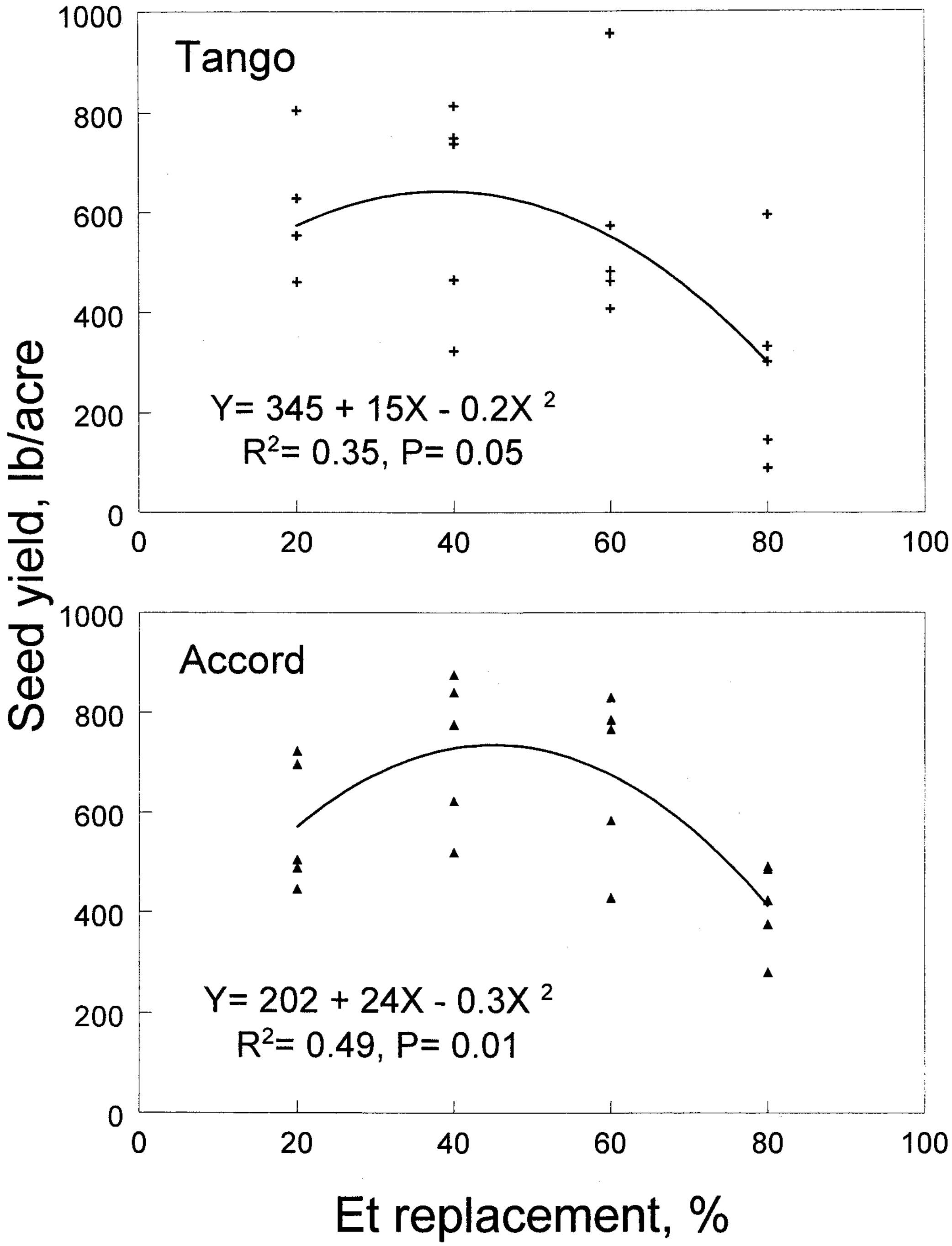


Figure 5. Alfalfa seed lygus bug population level. Arrows denote insecticide applications. A pre-bloom application was made on June 6. Malheur Experiment Station, Oregon State University, Ontario, OR.


Seed yield, lb/acre
Tango
Y= 345 + 15X - 0.2X 2
R2= 0.35, P= 0.05
Accord
Y= 202 + 24X - 0.3X 2
R2= 0.49, P= 0.01
Et replacement, %
0
20
40
60
80
100
200
400
600
800
1000

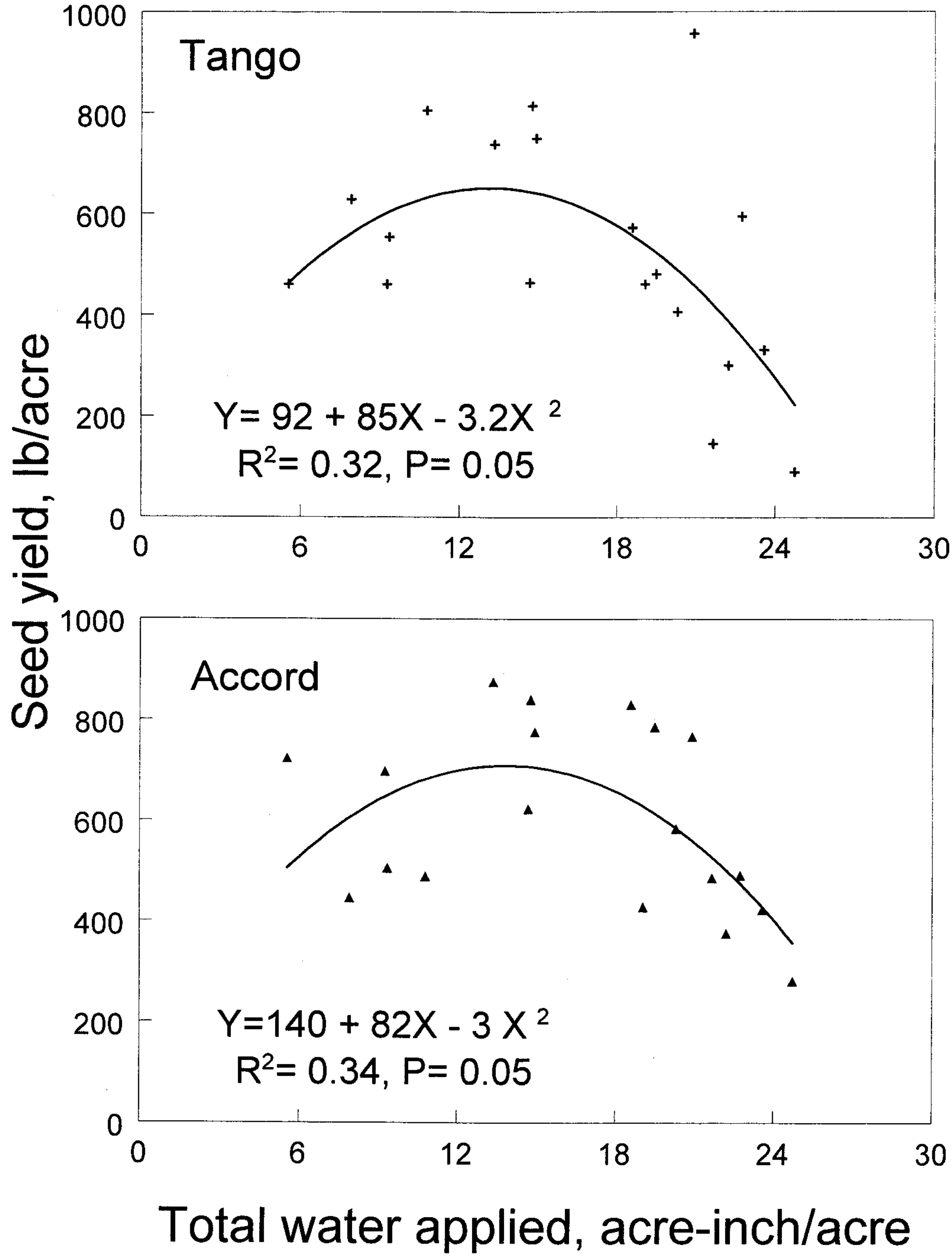


Figure 6. Alfalfa seed yield response to Et_c replacement. Both excessive water stress and abundant irrigation decreased seed yields. Malheur Experiment Station, Oregon State University, Ontario, OR.

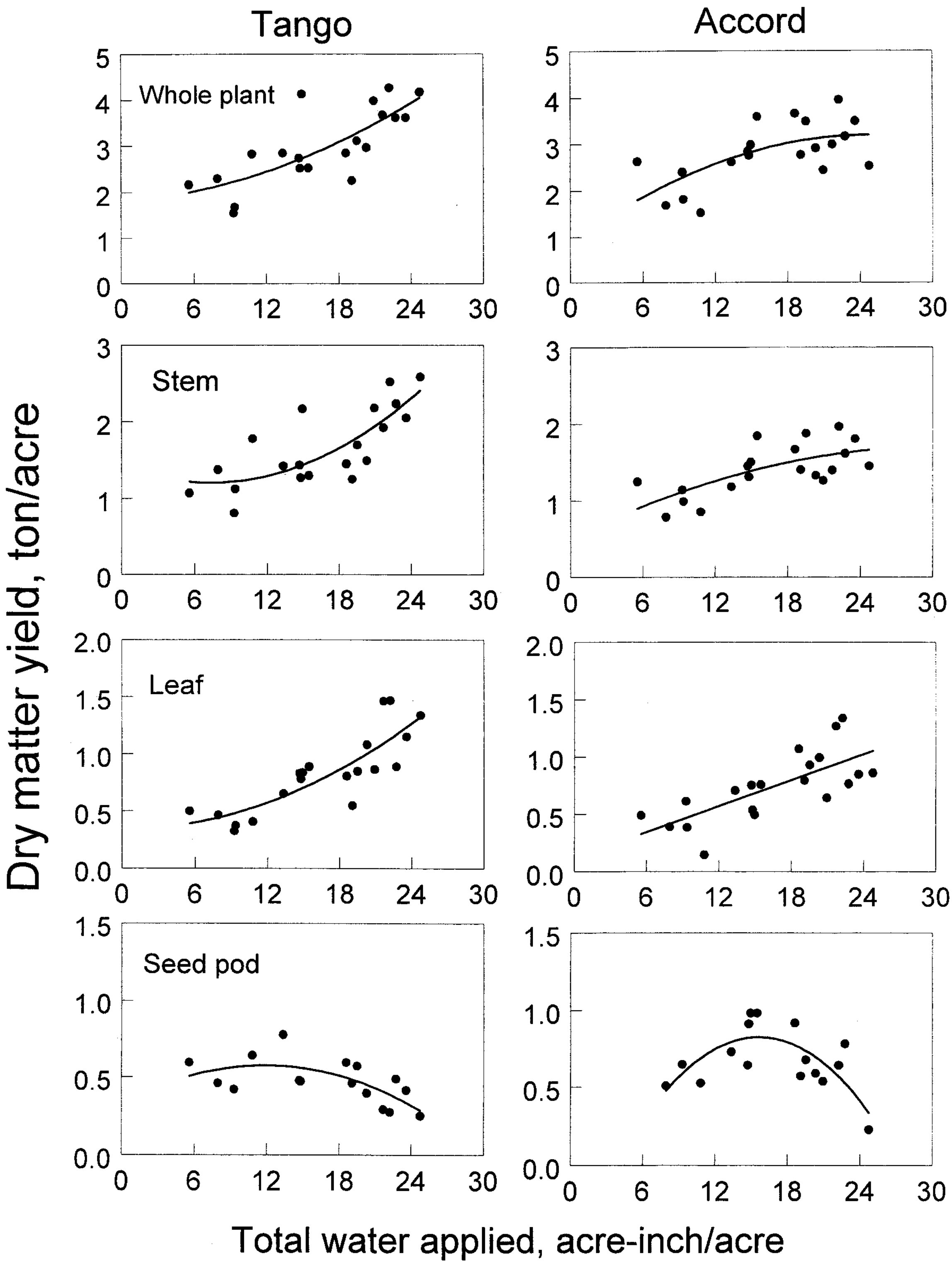


Figure 7. Alfalfa seed yield response to total water applied. Both excessive water stress and abundant irrigation decreased seed yields. Malheur Experiment Station, Oregon State University, Ontario, OR.

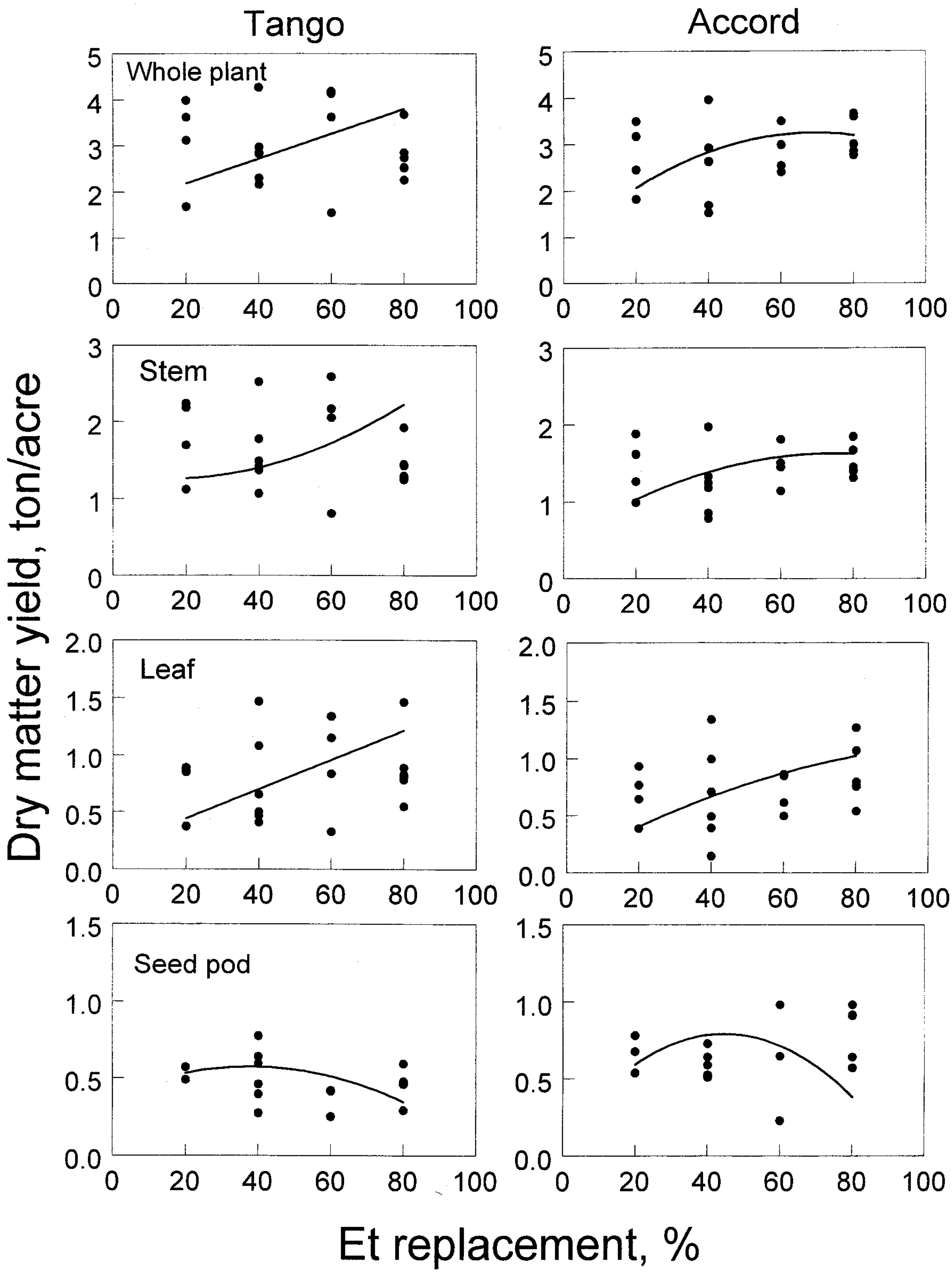


Figure 8. Response of alfalfa dry matter yield fraction to total water applied. Malheur Experiment Station, Oregon State University, Ontario, OR.

HERBICIDES FOR ALFALFA SETBACK AND PREHARVEST DESICCATION IN ALFALFA SEED PRODUCTION

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Introduction

Growers intensively delay early alfalfa development so that plant flowering coincides with warm weather, which is conducive for pollination by alfalfa leafcutting bees. In addition to herbicides being used for weed control, contact herbicides like paraquat sometimes are used to delay early season plant development by burning back alfalfa plants. "Setback" herbicides may be used instead of cultivation, therefore eliminating reduced stand and the spread of diseases that may occur during cultivation. With the introduction of several new contact herbicides, it is likely that some of these herbicides may be useful for delaying crop development to synchronize the onset of bloom with the optimum time of alfalfa leafcutting bee emergence and pollination activity.

Improved methods of desiccation continue to be of interest. Different herbicides will be compared to Gramoxone Extra that may give growers other options for preharvest desiccation.

Methods

General Procedures

Setback and desiccation trials were conducted on a cooperator's field near Ontario, Oregon. Alfalfa seed management practices were carried out by the grower. Treatments were applied with a CO_2-pressurized backpack sprayer delivering 20 gal/acre at 30 psi. Data were analyzed using ANOVA, and treatment means were separated using a protected least significant difference at the 5 percent level, LSD (0.05). Neither trial was harvested.

Alfalfa Setback

Treatments were applied on May 3 to alfalfa that was 6 - 14 inches tall. Plots were 10 ft wide and 30 ft long and replicated four times in a randomized complete block design. Treatments included three rates of Desiccant A at 2.0, 4.0, and 6.0 percent v/v and Gramoxone Extra plus a non-ionic surfactant (NIS) at 0.31 and 0.47 lb ai/acre. Desiccant A is a botanical-based herbicide developed privately in Michigan. Visual evaluations were taken for alfalfa setback on May 11, 8 days after treatment (DAT).

Preharvest Desiccation
Plots were 10 ft wide by 25 ft long. Treatments were replicated three times and arranged in a randomized complete block design. Applications were made on August 29. Treatments included Reglone (Diquat) alone at 0.25 ai/acre and Gramoxone Extra (0.625 lb ai/acre) alone and with Reglone at 0.25 lb ai/acre. Et 751 at the 0.012 lb ai/acre rate was tested alone and at the 0.006 lb ai/acre rate was tested with Reglone at the 0.25 and 0.5 lb ai/acre rate. Desiccant A was entered at the 8 and 10 percent v/v rate. Desiccant A at the 8 percent v/v rate was combined with Reglone at 0.25 lb ai/acre. All treatments included a crop oil concentrate (COC) at 1.0 qt/acre. Visual evaluations of foliage desiccation were recorded 3 and 7 DAT. Plant moisture content was determined 7 DAT by harvesting a sample from each plot, recording the fresh weight, drying for 48 hours, recording the dry weight, and using the fresh and dry weights to calculate percent moisture.

Results

Alfalfa Setback
Gramoxone Extra at 0.47 lb ai/acre provided crop setback significantly greater than all other treatments at 65 percent (Table 1). Gramoxone Extra at 0.31 lb ai/acre provided 51 percent defoliation. Desiccant A at the 2.0, 4.0, and 6.0 percent v/v rates provided only 4, 18, and 34 percent desiccation, respectively. Ratings were similar on May 7 and May 11.

Preharvest Desiccation
Seven days after applications were made, Gramoxone Extra plus Reglone and Gramoxone (0.625 lb ai/acre) desiccated alfalfa significantly greater than all other treatments (89 and 85 percent) (Table 2). Et 751 (0.006 lb ai/acre) plus Reglone and Desiccant A plus Reglone provided similar results at 60 and 53 percent. Et 751 (0.006 lb ai/acre) plus Reglone, Desiccant A at the 8 and 10 percent v/v rates, and Reglone alone at the 0.25 lb ai/acre rate were similar in activity (28-40 percent). Et 751 (0.012 lb ai/acre) alone did not differ from the untreated check. Biomass samples indicated that treatments containing Gramoxone Extra plus Reglone reduced percent alfalfa moisture content greater than all treatments except Gramoxone Extra alone. Biomass samples may have underestimated differences among treatments since more effective treatments caused desiccated leaves to fall to the ground. At the rates tested, Et 751 or Desiccant A applied alone were less effective than currently available desiccants.

Table 1. Alfalfa setback in response to chemical setback treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment*	Rate	Alfalfa setback 5-7	Alfalfa setback 5-11
		%	%
Desiccant A	2.0% v/v	4	4
Desiccant A	4.0% v/v	18	11
Desiccant A	6.0% v/v	34	26
Gramoxone Extra + NIS	0.31 lb ai/acre	51	51
Gramoxone Extra + NIS	0.47 lb ai/acre	65	63
No setback	--	0	1
LSD (0.05)		7	3

*NIS was applied at 0.25 percent v/v.

Table 2. Alfalfa desiccation and moisture content from herbicide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment*	Rate	Alfalfa desiccation 9-1	Alfalfa desiccation 9-5	Moisture content† 9-5
	lb ai/acre	%	%	%
Gramoxone Extra + Reglone	0.625 + 0.25	82	89	42
Et 751	0.012	12	8	54
Et 751 + Reglone	0.006 + 0.25	38	32	57
Et 751 + Reglone	0.006 + 0.5	63	60	49
Desiccant A	8% v/v	41	34	57
Desiccant A	10% v/v	43	28	58
Desiccant A + Reglone	8% v/v + 0.25	62	53	54
Reglone	0.25	38	40	58
Gramoxone Extra	0.625	71	85	44
Untreated	--	0	0	56
LSD (0.05)		13	17	10

*COC was added to all treatments at 1.0 qt/acre.
†Moisture content was calculated by weighing alfalfa before and after drying.

DEVELOPMENT OF NEW HERBICIDE OPTIONS FOR ALFALFA SEED PRODUCTION

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Introduction

Weed control during alfalfa establishment is critical for the production of weed-free alfalfa seed. Losses due to weeds include reduced yields from competition, difficulty at harvest, and contamination of the crop by weed seeds. The loss of 2,4-DB ester has limited the herbicide options available for alfalfa seed producers. Additionally, high temperatures during establishment can further restrict the herbicides that can be used without injury to the alfalfa crop. New herbicides offer potential to provide effective weed control during alfalfa establishment with minimal injury to the crop.

Methods

General Procedures

Two weed control trials were conducted on a cooperator's field in Adrian, Oregon. Alfalfa (var. Cal-West 'BN-12') was planted on March 25. Standard practices in planting, cultivation, irrigation, insect control, and pollination were used by the grower. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer delivering 20 gal/acre at 30 psi. Plots were 10 ft wide and 25 ft long and replicated three times in a randomized complete block design. In both trials, postemergence herbicide applications were made on May 22 to 3-inch-tall alfalfa. Crop injury and weed control were evaluated throughout the growing season. Data were analyzed using ANOVA, and treatment means were separated using a protected least significant difference at the 5 percent level, LSD (0.05). After the last weed control rating both trials were hand weeded because of high weed populations, therefore eliminating any differences that may have been determined by harvesting the trials. Neither trial was harvested.

Postemergence Tough Combinations

Treatments consisted of Buctril and 2,4-DB ester applied alone, Tough applied with and without crop oil concentrate (COC), and Butyrac 200 applied with and without a non-ionic surfactant (NIS). Combinations of Tough plus Butyrac 200, Basagran, or Buctril were evaluated. Basagran was applied with either Buctril or Butyrac 200. All tank-mix combinations included COC at 1 qt/acre. Air temperature at the time of application was 69°F. Weed control ratings were taken on common lambsquarters, hairy nightshade, Russian thistle, kochia, and annual sowthistle.

Raptor Rates and Additives

Raptor was applied at 0.032 and 0.048 lb ai/acre with either NIS, COC, or methylated seed oil (MSO). NIS was added at 0.25 percent v/v, COC at 1 percent v/v, and MSO at 1 percent v/v. Raptor plus Poast was also evaluated with either COC or MSO. All treatments contained 32 percent N at 1 percent v/v. The same weeds were present as in the previous trial. This trial also was not harvested due to high weed populations and hand weeding.

Results

Because weeds were large at the time of herbicide application, control declined rapidly as weeds outgrew the injury caused by the herbicides. The last visual evaluation was made 19 days after application, at which time both trials were terminated.

Postemergence Tough Combinations

On May 31, 9 days after treatment (DAT), all combinations that included Basagran showed injury between 37 and 48 percent (Table 1). Tough plus Buctril was also among the highest in crop injury with 45 percent. Even though temperatures were relatively cool following application, injury with Buctril was 20 percent. Crop injury with Tough, 2,4-DB ester, Butyrac 200, and Butyrac 200 plus NIS was not statistically different than the untreated check. On May 19, treatments that included Basagran and Tough plus Buctril continued to show significantly greater injury than the untreated check (13-27 percent).

On May 9, Tough was equal to 2,4-DB ester in common lambsquarters, Russian thistle, kochia, and sowthistle control. In most cases, Tough plus COC did not appear to have any weed control benefits over Tough alone. Treatments provided similar common lambsquarters control except Tough plus COC. The addition of NIS to Butyrac 200 significantly increased control of hairy nightshade, Russian thistle, kochia, and annual sowthistle. Generally, tank-mix combinations provided greater weed control than herbicides applied alone. On May 19, 2,4-DB ester was superior to Buctril, Butyrac 200, and Tough for control of common lambsquarters, hairy nightshade, kochia, and annual sowthistle.

Raptor Rates and Additives

On May 31, Raptor at both 0.032 and 0.048 lb ai/acre caused significant injury compared to the untreated check when either NIS or methylated seed oil (MSO) was added (Table 2). The addition of COC to Raptor did not cause an increase in crop injury. By June 9, only Raptor at 0.048 lb ai/acre plus MSO showed significant injury.

Raptor at 0.032 lb ai/acre plus MSO controlled common lambsquarters, hairy nightshade, kochia, and annual sowthistle significantly better than when NIS or COC were added. With Raptor at 0.048 lb ai/acre, weed control for all weed species was better with MSO than NIS or COC. Weed control was similar with treatments containing NIS or COC. Raptor at 0.048 lb ai/acre plus MSO was among the best treatment for all weeds evaluated but only provided between 77-85 percent control.

Table 1. Alfalfa injury and weed control with postemergence herbicides, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment*	Rate	Alfalfa injury 5-31	Alfalfa injury 6-9	Alfalfa injury 6-19	Weed control† Common lambsquarters	Hairy nightshade	Russian thistle	Kochia	Sow-thistle
	lb ai/acre	%							
Buctril	0.25	20	13	5	98	22	48	45	68
2,4-DB ester	0.5	2	5	0	98	72	83	83	77
Butyrac 200	0.5	2	0	0	97	3	27	17	12
Tough	0.94	7	5	0	63	13	57	50	22
Tough + COC	0.94	17	5	0	62	18	91	55	47
Butyrac 200 + Tough + COC	0.5 + 0.94	31	24	8	97	79	93	89	75
Basagran + Tough + COC	1.0 + 0.94	37	42	27	88	56	92	82	81
Basagran + Butyrac 200 +COC	1.0 + 0.5	41	31	13	98	48	98	84	84
Basagran + Buctril + COC	1.0 + 0.25	48	53	23	70	65	92	70	78
Tough + Buctril + COC	0.94 + 0.25	45	41	20	94	37	93	82	75
Butyrac 200 + NIS	0.5	11	10	2	98	80	78	87	61
Untreated		0	0	0	0	0	0	0	0
LSD (0.05)		11	13	10	31	28	32	27	16

*NIS was applied at 0.25 percent v/v and COC was applied at 1.0 qt/acre.
†Weed control ratings were taken on June 19.

Table 2. Alfalfa injury and weed control with Raptor rates and adjuvants, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment*	Rate	Alfalfa injury 5-31	Alfalfa injury 6-9	Weed control† Common lambsquarters	Hairy nightshade	Russian thistle	Kochia	Annual sowthistle
	lb ai/acre	%						
Raptor + NIS	0.032	7	0	25	42	45	38	28
Raptor + COC	0.032	3	0	30	46	57	63	48
Raptor + MSO	0.032	8	10	58	62	74	77	66
Raptor + NIS	0.048	11	2	27	40	55	66	50
Raptor + COC	0.048	0	0	27	44	53	62	37
Raptor + MSO	0.048	17	28	82	77	85	83	78
Raptor + Poast + COC	0.048+0.375	2	8	42	58	63	72	62
Raptor + Poast + MSO	0.048+0.375	7	5	70	72	72	80	73
Untreated		0	0	0	0	0	0	0
LSD (0.05)		5	11	21	18	18	11	17

*32 percent N solution (1 percent v/v) was added to all treatments. NIS was applied at 0.25 percent v/v and MSO was applied at 1.0 percent v/v.
†Weed control ratings were taken on June 9.

POSTEMERGENCE DOWNY BROME AND QUACKGRASS CONTROL IN ALFALFA

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Introduction

Downy brome and quackgrass compete with alfalfa, reducing alfalfa yield and quality. Postemergence grass herbicides are registered for use in alfalfa and may provide downy brome and quackgrass control. A trial was established to compare Select to Poast and evaluate Select plus Pursuit for crop tolerance and downy brome and quackgrass control.

Methods

The trial was conducted on a commercial field with a uniform infestation of downy brome and quackgrass near Nyssa, Oregon. General management practices were carried out by the cooperator. Plots were 10 ft wide by 30 ft long. Treatments included Select at 0.125 lb ai/acre applied with and without ammonium sulfate (AMS) at 2.5 lb/acre, Poast at 0.19 lb ai/acre with and without AMS, and Select (0.125 lb ai/acre) plus Pursuit (0.063 lb ai/acre). All treatments included a crop oil concentrate (COC) at 1.0 qt/acre. Treatments were replicated three times in a randomized complete block design. Applications were made when alfalfa and grasses were 5 - 6 inches tall on April 17. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer delivering 20 gal/acre at 30 psi. Plots were evaluated 11 and 22 days after treatment (DAT). Visual ratings included the percent of alfalfa plants injured and percent of weeds controlled. Hay yields were not taken.

Results

Alfalfa was not injured by any treatment (Table 1). For both evaluation dates, Select plus AMS and COC controlled downy brome and quackgrass significantly better than any other treatment. On April 28, downy brome control was similar with Select and COC (20 percent), Select plus Pursuit and COC (24 percent), and Poast plus AMS and COC (23 percent). By May 9, downy brome control for these three treatments increased to 58, 68, and 59 percent, respectively. On May 9, Select plus AMS and COC provided 85 percent downy brome control and 79 percent quackgrass control. Poast and COC 22 DAT rated 0 percent for both downy brome and quackgrass.

Table 1. Alfalfa injury and downy brome and quackgrass control in established forage alfalfa, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

		Alfalfa injury		Downy brome		Quackgrass	
Treatment*	Rate	4-28	5-9	4-28	5-9	4-28	5-9
	lb ai/acre	%					
Select	0.125	0	0	20	58	16	55
Select + AMS	0.125	0	0	35	85	31	79
Select + Pursuit	0.125 + 0.063	0	0	24	68	24	60
Poast	0.19	0	0	6	0	9	0
Poast + AMS	0.19	0	0	23	59	20	54
Untreated	--	0	0	0	0	0	0
LSD (0.05)		NS	NS	7	6	4	6

*COC (1.0 qt/acre) was added to all treatments. AMS was applied at 2.5 lb/acre.

WEED CONTROL AND CROP RESPONSE WITH HERBICIDES APPLIED IN CORN

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Introduction

Weed control is important in corn production to reduce competition to the crop and reduce the production of weed seeds for future crops. Field trials were conducted to evaluate postemergence herbicides for weed control and crop tolerance in furrow-irrigated field and sweet corn. Distinct is a selective postemergence herbicide providing control of annual broadleaf weeds in field corn. In general, field corn is very tolerant to Distinct application. However, temporary injury may result under conditions of crop stress or rapid growth. A trial was conducted to evaluate sweet corn tolerance to postemergence applications of Distinct. Two formulations of an experimental herbicide were evaluated for weed control and crop tolerance compared to currently registered herbicides in field corn.

Methods

General

The soil for the field trials was an Owyhee silt loam with a pH of 8.0, an organic matter content of 1.2 percent, and a cation exchange capacity of 15 meq/100g of soil. Plots measured 10 by 30 ft and were arranged in a randomized complete block having four replicates. Both trials were sidedressed on April 27 with 80 lbs N/acre as 46 percent urea, 8 lbs/acre Zn, and 1 lb/acre each of B, Cu, and Mn. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Data were analyzed using ANOVA, and treatment means were separated using Fishers protected LSD (0.05).

Weed Control in Field Corn

A trial was conducted at the Malheur Experiment Station comparing registered and experimental herbicides for weed control and crop safety in field corn. Novartis variety 'NK N3030' field corn was planted with a John Deere model 71 Flexi Planter on May 1. Seed spacing was one seed every 7 inches on 30-inch rows. Percent corn injury and percent weed control were evaluated throughout the growing season. Corn yield was determined October 4 by harvesting ears from 15-ft sections of the center two rows in each plot. On November 13 harvested ears were threshed and dry weight of the grain recorded. Grain yields were adjusted for 12 percent moisture.

Treatments included an Aventis numbered product in two formulations, AE F130360 WG70 and AE F130360 WG62. AE F 130360 WG 70 was applied at 0.066 lb ai/acre and AE F130360 WG62 was applied at 0.068 lb ai/acre. All treatments when AE

F130360 WG70 or AE F130360 WG62 were applied alone or in tank mix combinations included methylated seed oil (MSO) at 1.0 percent v/v and 32 percent N as urea at 2.5 percent v/v. AE F130360 WG70 was applied in combination with Distinct, Outlook, or Callisto as a tank mix. Distinct was applied alone with MSO and 32 percent N. Steadfast and Basis were applied alone with a crop oil concentrate (COC) at 1.0 percent v/v and 32 percent N. Dual II Magnum was applied preemergence followed by Callisto, MSO, and 32 percent N postemergence. Preemergence applications occurred on May 3 and all postemergence applications occurred on May 29 to 8-inch corn.

Sweet Corn Tolerance to Distinct

A trial was established at the Malheur Experiment Station to evaluate sweet corn tolerance to Distinct herbicide. 'Golden Jubilee' sweet corn was planted in 30-inch rows at a population of 29,300 seeds per acre with a John Deere model 71 Flexi Planter on May 1. Sweet corn injury and weed control were evaluated throughout the season. Corn was harvested from 20-ft sections of the two middle rows in each plot on August 6. After total plot yields were determined, a subsample of 10 ears was taken from each sample, the husks were removed, and the weight recorded. The length and diameter of each ear also was measured.

Distinct was applied as a total postemergence treatment or following preplant-incorporated or preemergence applications. Preplant-incorporated treatments consisted of Eradicane (3.14 lb ai/acre) alone or Eradicane plus AAtrex (0.75 lb ai/acre) applied on April 30. Preemergence applications of Prowl (0.83 lb ai/acre) and Outlook (0.66 lb ai/acre) were applied on May 3. Postemergence treatments applied on May 29 consisted of Distinct applied at either 0.0875 or 0.175 lb ai/acre plus a non-ionic surfactant (NIS) (0.25 percent v/v) with or without 32 percent N (1.25 percent v/v) or Basagran (0.75 lb ai/acre).

Results

Weed Control in Field Corn

On June 14, all treatments except Dual II Magnum applied preemergence followed by Callisto had crop injury that was significantly greater than the untreated check (Table 1). AE F130360 WG70 plus Distinct ranked among the highest in injury (25 percent) and showed significantly higher injury than AE F130360 WG70 plus Outlook and Steadfast or Basis alone. All treatments with either AE F130360 WG70 or AE F130360 WG62 had injury ratings between 19 and 25 percent. On June 28, 30 days after treatment (DAT), Steadfast, Distinct, and AE F130360 WG70 applied alone provided significant crop injury (15-23 percent).

On June 28, redroot pigweed control ranged from good to excellent (82-97 percent) with all treatments (Table 1). The addition of AE F130360 WG70 to Distinct significantly increased both redroot pigweed and barnyardgrass control compared to Distinct applied alone. Outlook provided greater control of redroot pigweed compared with Callisto when both were applied in a tank-mix with AE F130360 WG70. However, with the same treatment combinations Callisto provided greater control of common lambsquarters than Outlook. Only Dual II Magnum followed by Callisto and AE F130360 WG70 plus Callisto provided common lambsquarters control above 90 percent. AE F130360 WG70, Steadfast, and Basis when applied alone provided poor control of common lambsquarters (47-62 percent). Hairy nightshade control with Basis was significantly lower than all other treatments except Steadfast. All treatments that included either AE F130360 WG70 or AE F130360 WG62 provided good barnyardgrass control (88-96 percent). Dual II Magnum followed by Callisto and Distinct applied alone did not adequately control barnyardgrass.

All treatments increased yield significantly over the untreated check. There were no statistical differences in yield between any of the herbicide treatments.

Sweet Corn Tolerance to Distinct

Crop injury was apparent with all treatments on June 15 (17 DAT) and June 28 (30 DAT) (Table 2). In general, crop injury from postemergence applications of Distinct was similar regardless of rate. Injury was greater on both evaluation dates when 32 percent N was added to postemergence applications of Distinct (0.088 and 0.175 lb ai/acre) plus NIS following Eradicane plus AAtrex. Injury was greater on June 28 with the addition of 32 percent N to Distinct (0.175 lb ai/acre) plus NIS and with 32 percent N added to Distinct (0.175 lb ai/acre) plus NIS following a preplant-incorporated application of Prowl plus Outlook.

Regardless of Distinct rate, weed control was similar with total postemergence treatments of Distinct plus NIS (Table 2). However, when 32 percent N was added to these treatments, both redroot pigweed and common lambsquarters control was greater with Distinct at the higher rate of 0.175 lb ai/acre. In general, weed control was greater with treatments including preplant-incorporated or preemergence applications compared to total postemergence treatments.

Corn yield with postemergence treatments was among the lowest with Distinct (0.088 lb ai/acre) plus NIS and was most likely due to poor barnyardgrass control (Table 2). The addition of 32 percent N to this treatment increased yield by 37 cwt/acre. Corn yields from herbicide treatments ranged from 135 to 184 cwt/acre and were greatest with postemergence treatments including 32 percent N and treatments including either a preemergence or preplant-incorporated application followed by a postemergence application. There were no differences in cob diameter among treatments (data not shown). Cob length was generally greater with postemergence treatments including 32 percent N and treatments including either a preemergence or preplant-incorporated application followed by a postemergence application.

Table 1. Weed control and grain yield in field corn, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate*	Timing†	Corn injury 6-14	Corn injury 6-28	Weed control‡ Redroot pigweed	Weed control‡ Lambs-quarters	Weed control‡ Hairy nightshade	Weed control‡ Barnyard-grass	Corn yield
	lb ai/acre		%	%	%	%	%	%	bu/acre
AE F130360 WG70 + MSO + 32 % N	0.033 1.0% + 2.5%	POST	19	15	93	58	91	92	170
AE F130360 WG61 + MSO + 32 % N	0.034 1.0% + 2.5%	POST	22	11	89	77	88	88	174
AE F130360 WG70 + Distinct + MSO + 32 % N	0.033 0.175 1.0% + 2.5%	POST	25	9	91	88	93	89	192
Distinct + MSO + 32 % N	0.17 1.0% + 2.5%	POST	19	19	85	88	90	9	186
AE F130360 WG70 + Outlook + MSO + 32 % N	0.033 0.64 1.0% + 2.5%	POST	18	6	92	78	96	96	177
AE F130360 WG70 + Callisto + MSO + 32 % N	0.033 0.063 1.0% + 2.5%	POST	21	1	82	91	93	89	189
Steadfast + COC + 32 % N	0.03 1.0% + 2.5%	POST	16	23	97	47	80	96	170
Basis + COC + 32 % N	0.01 1.0% + 2.5%	POST	17	13	97	62	73	85	187
Dual II Magnum + Callisto	1.3 0.094	PRE POST	4	0	86	97	92	73	197
Untreated	--	--	0	0	0	0	0	0	117
LSD (0.05)			6	11	5	11	14	12	28

*Methylated seed oil (MSO) and crop oil concentrate (COC) were applied at 1.0 percent v/v and 32 percent N was applied at 2.5 percent v/v.

†Preemergence (PRE) application was made on May 3 and postemergence applications were made on May 29.

‡Weed control evaluations were taken on June 28, 30 days after postemergence (POST) applications.

Table 2. Crop injury, weed control, and yield with Distinct in sweet corn, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate*	Timing[†]	Sweet corn injury 6-15	Sweet corn injury 6-28	Weed control[‡] Redroot pigweed	Weed control[‡] Lambs-quarters	Weed control[‡] Barnyard-grass	Corn yield[§]	Ear length
	lb ai/acre		%	%	%	%	%	cwt/acre	inches
Distinct + NIS	0.088+ 0.25%	POST	8	12	83	93	31	135	17.2
Distinct + NIS + 32 % N	0.088 + 0.25% + 1.25%	POST	10	9	80	87	40	172	17.5
Distinct + NIS	0.175 + 0.25%	POST	12	11	87	92	46	157	17.2
Distinct + NIS + 32 % N	0.175 + 0.25% + 1.25%	POST	19	21	93	94	64	165	17.6
Eradicane + AAtrex Distinct + NIS	3.14 + 0.75 0.088 + 0.25%	PPI POST	3	4	99	100	100	169	18.1
Eradicane + AAtrex Distinct + NIS + 32 % N	3.14 + 0.75 0.088 + 0.25% + 1.25%	PPI POST	17	11	99	100	95	168	17.7
Eradicane + AAtrex Distinct + NIS	3.14 + 0.75 0.175 + 0.25%	PPI POST	12	5	100	100	95	171	18.1
Eradicane + AAtrex Distinct + NIS + 32 % N	3.14 + 0.75 0.175 + 0.25% + 1.25%	PPI POST	20	14	100	100	100	172	17.7
Prowl + Outlook Distinct + NIS	0.83 + 0.66 0.088 + 0.25%	PRE POST	5	4	97	99	96	174	18.1
Prowl + Outlook Distinct + NIS + 32 % N	0.83 + 0.66 0.088 + 0.25% + 1.25%	PRE POST	12	7	100	100	99	184	18
Prowl + Outlook Distinct + NIS	0.83 + 0.66 0.175 + 0.25%	PRE POST	10	7	99	100	100	174	18
Prowl + Outlook Distinct + NIS + 32 % N	0.83 + 0.66 0.175 + 0.25% + 1.25%	PRE POST	16	21	100	100	100	175	17.6
Distinct + Basagran + NIS	0.175 + 0.75 + 0.25%	POST	10	7	90	98	50	146	17.8
Eradicane Distinct + NIS + 32 % N	3.14 0.175 + 0.25% + 1.25%	PPI POST	19	16	100	100	100	168	17.8
Untreated	--	--	0	0	0	0	0	61	16.2
LSD (0.05)			7	6	6	5	29	20	0.7

*Non-ionic surfactant (NIS) was applied at 0.25 percent v/v and 32 percent N at 1.25 percent v/v.

[†]Preplant-incorporated (PPI), preemergence (PRE), and postemergence applications were made on April 30, May 3, and May 29, respectively.

[‡]Weed control evaluations were taken on June 28, 30 days after postemergence (POST) applications.

[§]Corn yield and ear lengths were taken on August 7.

YELLOW NUTSEDGE CONTROL IN DRY EDIBLE BEANS WITH SANDEA®

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Introduction

Yellow nutsedge is an increasingly difficult weed to control in several crops in the Treasure Valley, including dry beans. Few herbicides labeled for postemergence application in dry beans provide effective yellow nutsedge control. Sandea is labeled for broadleaf weed and yellow nutsedge control in sweet corn. Postemergence applications of Sandea were evaluated at various rates alone and in combination with several premergence herbicides for crop tolerance and yellow nutsedge control in dry beans.

Methods

Pinto beans (var. 'Othello') were planted on May 4 using a 2-inch seed spacing. Due to poor crop establishment, Roundup (0.75 lb ai/acre) was applied on May 17 to facilitate replanting on May 23. Plots four rows wide and 27 ft long were arranged in a randomized complete block. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Crop injury and yellow nutsedge control were evaluated throughout the season. Sandea was applied postemergence at rates of 0.5 and 0.75 oz ai/acre, and preemergence at rates of 0.56, 0.75, and 0.94 oz ai/acre. Applications of Sandea applied alone or in combination with Basagran were evaluated as a total postemergence treatment or following preemergence applications of Dual II Magnum or Outlook.

Results

Crop injury on June 19 ranged from 0 to 30 percent and was greatest in plots receiving postemergence Sandea applications (Table 1). Crop injury was less with postemergence applications of Sandea (0.752 oz ai/acre) plus Basagran (16 oz ai/acre) compared to Sandea alone (0.752 oz ai/acre). On July 30, only plots receiving a second postemergence application of Sandea with or without Basagran displayed injury greater than the untreated check. Injury was again greater with Sandea alone compared with the combination of Sandea plus Basagran on July 30.

On July 30, yellow nutsedge control was similar in plots receiving postemergence applications of Sandea regardless of rate, tank-mix combination, or number of applications (Table 1). Yellow nutsedge control with preemergence Sandea treatments was similar to both Dual II Magnum and Outlook. Sandea applied postemergence following Dual II Magnum and Outlook increased yellow nutsedge control by 29 and 21 percent, respectively, compared to the preemergence treatments alone.

Table 1. Dry bean injury and yellow nutsedge control with Sandea, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Dry bean injury			Yellow nutsedge control		
Treatment	Rate*	Timing†	6-19	7-3	7-13	7-3	7-13	7-30
	oz ai/acre		%					
Sandea + NIS	0.752 + 0.25%	1-2 Trif	30	18	1	84	95	97
Sandea + NIS Sandea + NIS	0.5 + 0.25% 0.5 + 0.25%	1-2 Trif 21 DL	27	16	25	75	91	97
Sandea + NIS Sandea + NIS	0.752 + 0.25% 0.752 + 0.25%	1-2 Trif 21 DL	24	13	26	76	94	97
Sandea	0.56	PRE	0	4	0	79	85	89
Sandea	0.75	PRE	6	4	2	60	62	68
Sandea	0.94	PRE	0	0	0	51	65	78
Dual II Magnum	20.3	PRE	4	5	0	27	49	66
Outlook	10.5	PRE	5	3	0	46	63	72
Dual II Magnum Sandea + NIS	20.3 0.752 + 0.25%	PRE 1-2 Trif	28	16	4	92	94	95
Outlook Sandea + NIS	10.5 0.752 + 0.25%	PRE 1-2 Trif	28	13	2	81	92	93
Sandea + Basagran + NIS	0.752 + 16 + 0.25%	1-2 Trif	16	6	1	81	93	89
Sandea + Basagran + NIS Sandea + Basagran + NIS	0.752 + 16 + 0.25% 0.752 + 16 + 0.25%	1-2 Trif 21 DL	20	12	13	89	96	97
Raptor + NIS	0.49 + 0.25%	1-2 Trif	20	13	0	38	38	53
Basagran + COC Basagran + COC	16 + 1.0% 16 + 1.0%	1-2 Trif 21 DL	13	6	4	60	86	88
Outlook Basagran + COC	10.5 16 + 1.0%	PRE 1-2 Trif	15	9	1	63	58	70
Untreated	--	--	2	0	0	3	0	15
LSD (0.05)			6	7	5	32	23	24

*Non-ionic surfactant (NIS) and crop oil concentrate (COC) were applied at 0.25 and 1.0 percent v/v.
†Preemergence (PRE) applications were made on May 25, postemergence applications made to 1 to 2 trifoliate (1-2 Trif) beans on June 15, and 21 days later (21 DL) to 10 to 14 trifoliate beans on July 6.

COMMON GROUNDSEL CONTROL IN MINT WITH SPRING POSTEMERGENCE HERBICIDE APPLICATIONS

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Introduction

Weed control in mint is essential in order to maintain high mint oil yields and quality. Reducing competition from weeds may prolong the productive life of a mint stand. Common groundsel is becoming established in the Treasure Valley and can be difficult to control in mint. Effective herbicide programs for controlling common groundsel in mint need to be identified.

Methods

A trial was established in a cooperator's field that had a dense population of common groundsel. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were 10 ft wide and 30 ft long and treatments were arranged in a randomized complete block design with four replications. Treatments were applied on March 22 to mint that was approximately 1/4 inch tall and to 2-inch-high common groundsel. Treatments included Buctril (0.25 lb ai/acre), Stinger (0.124 lb ai/acre), Goal (0.094 lb ai/acre), Gramoxone Extra (0.47 lb ai/acre), and Tough (0.94 lb ai/acre) applied alone and in various combinations. Mint injury and common groundsel control were visually evaluated on March 28, April 13, May 2, and May 16. Data were analyzed using ANOVA, and treatment means were separated using a protected least significant difference at the 5 percent level, LSD (0.05).

Results

Treatments containing Gramoxone Extra caused among the highest injury 6 and 22 days after treatment (DAT) (Table 1). Injury from Gramoxone Extra was attributed to application to non-dormant mint and was characterized by burning of mint foliage. Injury 55 DAT ranged from 0 to 19 percent and was greater with treatments including Gramoxone Extra or Buctril.

Common groundsel control 22 DAT ranged from 36 to 98 percent and was greatest in plots treated with Gramoxone Extra and with Buctril applied with either Stinger or Tough (Table 1). Common groundsel control with Stinger plus a non-ionic surfactant increased 62 percent between April 13 (22 DAT) and May 16 (55 DAT). While groundsel control with Stinger was low initially, it effectively suppressed the groundsel and allowed the mint to form a canopy over the row. All treatments except Goal plus crop oil concentrate and Tough plus crop oil concentrate provided greater than 85 percent control of common groundsel on May 16 (55 DAT).

Table 1. Mint injury and common groundsel control with postemergence herbicides, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

		Mint injury				Groundsel control		
Treatment*	Rate†	3-28	4-13	5-2	5-16	4-13	5-2	5-16
	lb ai/acre	%						
Buctril	0.25	5	7	7	16	64	80	85
Stinger + NIS	0.124 + 0.25%	10	0	6	8	36	88	98
Goal + COC	0.094 + 1.0%	38	16	6	1	37	59	53
Gramoxone Extra + NIS	0.47 + 0.25%	68	35	13	19	97	97	97
Buctril + Stinger	0.25 + 0.124	4	6	9	14	93	98	98
Gramoxone Extra + Goal + COC	0.47 + 0.094 + 1.0%	70	34	16	18	98	98	98
Tough + COC	0.94 + 1.0%	5	4	4	3	42	73	78
Gramoxone Extra + Goal + Buctril	0.47 + 0.094 + 0.125	63	43	16	15	98	96	96
Buctril + Tough + COC	0.25 + 0.94 + 1.0%	4	21	11	13	96	98	96
Untreated	--	4	0	3	0	0	0	0
LSD (0.05)		8	8	NS	10	8	13	14

*Treatments were applied on March 22.
†Non-ionic surfactant (NIS) and crop oil concentrate (COC) were applied at 0.25 and 1.0 percent v/v, respectively.

2001 ONION VARIETY TRIAL

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Introduction

The objective of this trial was to evaluate yellow, white, and red onion varieties for bulb yield and quality. Onions were graded out of storage in January 2002. Yellow bulb varieties were rated for single centers.

Methods

The 2001 trial was conducted on an Owyhee silt loam with 2.1 percent organic matter and a pH of 7.2. The field had previously been planted to wheat. In the fall of 2000, 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. Before plowing, 20 lb N/acre, 200 lb P_2O_5/acre, 28 lb K, 150 lb S/acre, 28 lb Mg/acre, 10 lb Zn/acre, and 5 lb Cu/acre were broadcast.

Beds were knocked down March 21, 2001. On March 22, seed of 51 varieties from 10 companies was planted in plots four rows wide and 27 ft long (Table 1, Fig. 1). The experimental design was a randomized complete block with five replicates. An extra sixth non-randomized replicate was planted for purposes of demonstrating onion variety performance to growers and seed company representatives. The onion seed was planted at 18 seeds per ft of row in single rows on beds spaced 22 inches apart using four Almaco cone seeders mounted on a John Deere Model 71 Flexi Planter 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 25. On May 11, alleys 4 ft wide were cut between plots, leaving plots 23 ft long. From May 11 through 14, the seedlings were hand thinned to a plant population of four plants per ft of row (3-inch spacing between individual onion plants, or 95,000 plants/acre). The field was sidedressed with 100 lb N/acre, 10 lb Zn/acre, 1 lb Cu/acre, and 1 lb B/acre on May 21. On June 21, 100 lb N/acre was water run as urea ammonium nitrate solution (uran).

The trial was managed to avoid yield reductions from weeds, pests, and diseases with moderate amounts of control. Weeds were controlled with cultivations on May 20 and June 19, and with low-rate herbicide applications as needed until lay-by (Goal at 0.031 lb ai/acre, Buctril at 0.16 lb ai/acre, and Poast at 0.26 lb ai/acre on May 19 and Prowl at 0.83 lb ai/acre on May 30). After lay-by the field was hand weeded as necessary. Thrips were controlled with four aerial applications of Warrior and Lannate (June 30, July 20, August 1, and August 18) and one aerial application of Warrior on June 11. Warrior was applied at 0.03 lb ai/acre and Lannate was applied at 0.26 lb ai/acre.

The trial was furrow irrigated when the soil water potential at 8-inch depth reached -25 kPa. Soil water potential was monitored by six granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co. Inc., Riverside, CA) installed on June 7 below the onion row at 8-inch depth. Sensors were automatically read three times a day with an AM-400 meter (Mike Hansen, East Wenatchee, WA). The last irrigation was on August 31.

The onions were lifted on September 10 to field dry. Onions from the middle two rows of every plot were topped, and bagged by hand on September 17. The onions were placed into storage on September 21. The storage shed was managed to maintain an air temperature of approximately 34°F.

In early September bulbs from one of the border rows in each plot of yellow onions were rated for single centers. Twenty-five consecutive onions ranging in diameter from 3.5 to 4.25 inches were rated. The onions were cut equatorially through the bulb middle and, if multiple centered, the long axis of the inside diameter of the first single ring was measured. These multiple-centered onions were ranked according to the diameter of the first single ring: "small double" had diameters <1½ inch, "intermediate double" had diameters from 1½ to 2¼ inch, 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."

Onions were graded out of storage in early January 2002. 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 to 3 inch), jumbo (3 to 4 inch), colossal (4 to 4¼ inch), and supercolossal (>4¼ inch). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading. Varietal differences were compared using ANOVA and least significant differences at the 5 percent probability level, LSD (0.05).

Results and Discussion

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. The percentage of "bullet" single centers averaged 28.5 percent and ranged from 6.7 percent for 'Delgado' to 70 percent for 'Vaquero' (Table 1). 'Vaquero', 'Sabroso', and 'Granero' were among the highest in percentage of "bullet" single centers. The percentage of onions that were functionally single centered averaged 53 percent and ranged from 24.7 percent for 'T-434' to 91.3 percent for 'Sabroso'. 'Sabroso', 'Vaquero', 'Granero', and 'Gunnison' were among the highest varieties in percentage of functionally single-centered bulbs.

Total yield out of storage in January, 2002 averaged 851.1 cwt/acre and ranged from 477.9 cwt/acre for 'Sabroso' to 1191.6 cwt/acre for 'T-433' (Table 2). 'T-433', 'Quest', 'T-434', 'Torero', and 'Superstar' were among the highest varieties in total yield. Supercolossal-size onion yield averaged 173 cwt/acre and ranged from 0 cwt/acre for 'T-441', 'Gunnison', 'Redwing', 'Flamenco', and 'Tango' to 483 cwt/acre for 'Quest'. 'Quest' was the highest yielding variety of supercolossal bulbs. The number of bulbs per 50 lb of supercolossal onions averaged 31 and ranged from 24 for 'Vaquero' to 59 for 'Red October'. Yellow bulb varieties that had supercolossal counts above the acceptable range (averaged too small) for marketing (28-36 count per 50 lb) were 'Daytona', 'Delgado', 'Legend', 'Sabroso', and 'Valiant'. 'Vaquero' had a supercolossal count below the acceptable range for marketing (averaged too big). Colossal-size onion yield averaged 258.1 cwt/acre and ranged from 18.6 cwt/acre for 'Red October' to 478.3 cwt/acre for 'Torero'. 'Torero', 'Vaquero', 'T-433', 'Santa Fe', 'Granero', 'Ranchero', 'Superstar', and 'Tequila' had colossal bulb yields greater than 400 cwt/acre.

Decomposition in storage averaged 10.5 percent and ranged from 3.6 percent for 'Daytona' to 26.6 percent for 'Red October'. No. 2 bulbs averaged 65.7 cwt/acre and ranged from 0 cwt/acre for 'Sweet Perfection' to 381.3 cwt/acre for 'T-434'. Bolting averaged 0.5 bolted onions out of approximately 368 onions in each 4-row plot. Bolting ranged from 0 bolted onions per plot for many varieties to only 2.4 bolted onions per plot for 'Zorro'.

Table 1. Yellow onion multiple center rating. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Seed company	Variety	"Blowout"	"Intermediate double"	"Small double"	"Bullet"	Functionally single centered "Bullet + small double"
		%				
American Takii	Eagle	18.8	34.3	36.9	10.1	47.0
	T-433	31.4	30.5	17.4	20.7	38.1
	T-434	49.3	26.0	14.0	10.7	24.7
	T-439	33.3	24.7	24.0	18.0	42.0
	T-441	6.0	31.3	38.0	24.7	62.7
Asgrow	Cannon Ball	29.3	24.0	18.7	28.0	46.7
	Santa Fe	13.3	16.0	36.7	34.0	70.7
	EX77031	19.5	31.4	22.1	26.9	49.0
	EX15120	19.6	29.6	23.4	27.5	50.9
Bejo	Daytona	30.5	34.4	22.8	12.3	35.1
	Delgado	42.0	30.0	21.3	6.7	28.0
	Gunnison	6.0	15.3	35.3	43.3	78.7
	Legend	38.0	34.7	19.4	7.9	27.3
Crookham	Sweet Perfection	13.8	23.7	21.0	41.5	62.5
	Zorro	23.8	19.8	23.9	32.5	56.4
	XPH97H33	21.3	30.7	21.3	26.7	48.0
	XPH95345	41.8	27.8	21.9	8.5	30.4
D. Palmer	Mesquite	28.7	35.3	21.3	14.7	36.0
	Tequila	21.6	18.0	25.5	34.9	60.4
Dorsing	Harvest Moon	22.9	28.6	23.4	25.1	48.6
Petoseed	Pinnacle	21.5	33.6	23.4	21.5	44.9
	Quest	19.3	24.0	28.0	28.7	56.7
	Tioga	21.3	34.0	26.0	18.7	44.7
	Vision	16.0	17.3	25.3	41.3	66.7
Rispens	Golden Security	37.5	27.6	18.1	16.8	34.8
	Ringstar	25.3	29.3	19.3	26.0	45.3
	Superstar	10.7	24.7	34.7	30.0	64.7
Seed Works	Pathfinder	45.4	22.8	18.2	13.5	31.7
	Raptor	30.0	23.3	20.0	26.7	46.7
	SWO 7102	8.0	16.0	30.0	46.0	76.0
	SWO 7254	18.7	25.3	28.0	28.0	56.0
	SWO 12028	21.5	22.2	22.1	34.2	56.3
Sunseeds	Granero	8.0	12.0	25.3	54.7	80.0
	Ranchero	8.0	20.7	22.0	49.3	71.3
	Sabroso	1.3	7.3	30.0	61.3	91.3
	Tesoro	33.3	28.7	20.7	17.3	38.0
	Torero	12.1	28.9	31.4	27.6	59.0
	Valiant	9.3	14.5	29.9	46.3	76.2
	Vaquero	8.7	8.0	13.3	70.0	83.3
Mean		22.2	24.8	24.5	28.5	53.0
LSD (0.05)		9.7	11.1	11.4	12.0	13.2

Table 2. 2001 performance data for experimental and commercial onion varieties graded out of storage, January, 2002, Malheur Experiment Station, Oregon State University, Ontario, OR.

Company	Entry name	Bulb color	Total yield	Marketable yield by grade: Total	>4¼ in	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Non-marketable yield: Total rot	Neck rot	Plate rot	Black mold	No. 2s	Small	Maturity: Aug. 20	Sept. 7	Bolters: Sept. 7
			--- cwt/acre ---		#/50 lb	------------ cwt/acre ------------				----- % of total yield -----				-- cwt/acre --		---- % ----		#/plot
American Takii	Eagle	Y	731.9	636.1	33	17.1	242.0	367.5	9.6	9.0	7.1	1.9	0.0	28.5	1.4	26.0	71.0	0.0
	T-433	Y	1191.6	980.2	29	316.0	446.0	211.4	6.8	9.7	5.6	4.0	0.2	94.9	0.8	10.0	34.0	0.8
	T-434	Y	1132.2	645.9	30	141.8	307.0	190.1	7.0	8.4	6.7	1.6	0.2	381.3	1.5	12.0	52.0	0.0
	T-439	Y	893.0	732.6	31	80.3	378.0	265.4	8.9	8.9	4.4	4.5	0.0	78.4	2.7	52.0	87.5	0.6
	T-441	Y	645.3	588.9		0.0	45.7	521.4	21.8	7.1	4.7	2.3	0.1	1.3	8.5	67.0	96.5	0.2
Asgrow	Cannon Ball	Y	1036.2	825.3	30	200.8	393.3	226.0	5.2	12.5	9.6	2.8	0.1	78.2	1.7	9.0	44.0	2.2
	Red Zepplin	R	631.3	421.2	54	1.0	53.1	341.0	26.1	12.4	11.1	1.3	0.0	126.8	5.4	55.0	85.5	0.0
	Santa Fe	Y	1013.6	866.4	31	143.5	442.1	267.4	13.5	9.5	7.3	2.2	0.0	47.8	3.1	16.0	51.0	1.4
	EX77031	Y	943.9	801.2	32	135.7	390.1	268.3	7.1	9.9	7.4	2.1	0.3	47.6	0.9	24.0	54.0	1.2
	EX15120	Y	889.5	785.8	33	55.1	326.9	397.9	5.9	6.9	5.2	1.7	0.0	39.6	2.9	28.0	62.0	0.2
Bejo	Daytona	Y	765.1	686.2	45	10.7	195.1	455.1	25.3	3.6	2.4	1.2	0.0	36.6	14.7	20.0	60.0	0.0
	Delgado	Y	815.5	700.0	38	16.8	211.9	460.0	11.3	9.0	5.9	3.0	0.1	38.7	3.3	31.0	69.0	0.0
	Gladstone	W	783.4	603.3	37	24.8	171.1	393.9	13.5	17.9	16.2	1.7	0.0	34.6	5.0	27.0	66.0	0.6
	Gunnison	Y	619.3	567.9		0.0	27.6	515.9	24.4	7.0	3.6	3.3	0.0	2.4	5.5	71.0	99.0	0.0
	Legend	Y	866.9	770.1	38	19.8	201.1	526.8	22.4	5.1	3.7	1.4	0.0	43.4	9.4	23.3	66.7	0.0
	Redwing	R	728.8	654.8		0.0	87.1	547.3	20.4	8.5	6.9	1.5	0.0	5.5	7.8	22.0	62.0	0.0
Crookham	Sweet Perfection	Y	983.5	726.8	31	234.8	334.6	148.7	8.8	22.6	20.0	2.5	0.0	29.2	1.3	16.0	53.0	1.0
	Zorro	Y	969.8	802.4	31	235.2	362.2	195.9	9.2	10.3	8.8	1.6	0.0	68.1	2.1	13.0	50.0	2.4
	XPH97H33	Y	966.4	754.7	32	157.2	366.8	222.8	8.0	12.5	10.5	2.1	0.0	88.8	1.2	18.0	49.0	0.6
	XPH95345	Y	893.3	703.3	32	86.9	279.2	327.8	9.5	9.4	8.6	0.9	0.0	104.7	2.0	12.0	48.0	0.4
D. Palmer	Frosty	W	733.7	493.6	35	7.4	159.2	319.1	7.8	25.0	19.9	5.1	0.0	53.2	2.8	31.0	68.0	0.6
	Mesquite	Y	1008.7	766.9	32	217.4	319.8	218.6	11.1	17.5	15.6	1.9	0.0	62.1	2.1	7.5	37.0	1.6
	Tequila	Y	1043.3	884.9	31	217.0	404.8	253.9	9.2	7.9	6.8	1.2	0.0	74.6	1.3	8.5	41.0	0.8
Dorsing	Harvest Moon	Y	684.5	540.6	31	173.0	226.0	133.1	8.5	10.5	9.2	1.3	0.0	70.5	3.1	15.8	51.7	1.0
	Red October	R	522.4	303.6	59	3.7	18.6	251.4	29.9	26.6	23.6	3.1	0.0	74.3	7.4	72.0	100.0	0.0

Table 2. 2001 performance data for experimental and commercial onion varieties graded out of storage, January, 2002, Malheur Experiment Station, Oregon State University, Ontario, OR.

Company	Entry name	Bulb color	Total yield	Marketable yield by grade: Total	Marketable yield by grade: >4¼ in	Marketable yield by grade: >4¼ in	Marketable yield by grade: 4-4¼ in	Marketable yield by grade: 3-4 in	Marketable yield by grade: 2¼-3 in	Non-marketable yield: Total rot	Non-marketable yield: Neck rot	Non-marketable yield: Plate rot	Non-marketable yield: Black mold	Non-marketable yield: No. 2s	Non-marketable yield: Small	Maturity: Aug. 20	Maturity: Sept. 7	Bolters: Sept. 7
			--- cwt/acre ---		#/50 lb	------------ cwt/acre ------------				----- % of total yield -----				-- cwt/acre --		---- % ----		#/plot
Petoseed	Flare	R	786.7	569.4	30	31.3	178.0	345.3	14.8	7.4	5.9	1.5	0.0	158.0	1.7	36.0	76.5	0.0
	Mercury	R	679.6	464.6	33	6.4	110.1	327.7	20.5	16.6	13.2	3.4	0.0	100.2	4.5	56.0	92.5	0.0
	Pinnacle	Y	878.4	735.5	34	32.1	296.9	394.1	12.3	11.1	8.6	2.6	0.0	43.6	2.4	41.0	74.5	0.0
	Quest	Y	1138.6	961.6	29	483.2	375.4	96.7	6.3	12.2	9.3	3.0	0.0	27.6	0.0	7.5	45.0	0.4
	Tioga	Y	974.7	915.4	31	54.3	388.9	462.4	9.8	4.8	2.6	2.2	0.0	9.0	2.7	34.0	66.0	0.2
	Vision	Y	986.8	836.8	31	197.3	385.6	245.6	8.3	11.9	8.6	3.2	0.2	31.7	1.6	19.0	56.0	0.2
Rispens	Golden Security	Y	817.6	636.3	33	56.0	272.3	292.6	15.4	8.4	6.7	1.8	0.0	110.8	2.8	17.0	57.0	1.4
	Red Fortress	R	660.4	443.6	48	2.2	67.6	359.5	14.3	10.4	8.1	2.3	0.0	141.6	6.9	19.5	62.0	0.4
	Red Rider	R	644.0	319.7	41	2.5	44.6	252.3	20.2	7.8	5.9	1.8	0.1	271.0	3.9	24.0	62.0	0.0
	Ringstar	Y	995.4	786.2	31	219.2	350.0	212.0	5.0	12.1	10.7	1.3	0.0	88.0	1.7	13.0	47.0	0.6
	Superstar	Y	1058.9	881.2	31	228.6	416.5	230.4	5.7	9.8	8.2	1.6	0.0	73.6	0.8	9.5	45.0	1.4
Seed Works	Pathfinder	Y	815.2	636.4	33	15.8	198.6	415.1	6.9	11.3	10.2	1.1	0.0	85.2	1.4	49.0	73.5	0.4
	Raptor	Y	971.0	690.3	32	131.3	291.7	260.2	7.1	19.2	15.1	4.1	0.0	94.8	1.8	16.0	49.0	1.2
	SWO 7102	Y	728.5	661.7	33	11.0	196.6	441.4	12.7	7.5	5.5	2.0	0.0	8.6	4.2	48.0	81.0	0.0
	SWO 7254	Y	883.2	740.9	31	108.9	330.2	290.9	11.0	9.5	7.5	2.0	0.0	53.1	3.5	22.0	56.0	0.2
	SWO 12028	Y	903.0	702.6	30	197.1	258.5	230.0	17.1	14.9	12.8	2.2	0.0	62.7	2.6	26.0	60.0	1.4
Sunseeds	Flamenco	R	541.4	437.4		0.0	11.8	385.4	40.2	11.6	9.0	2.6	0.0	33.5	7.0	70.0	100.0	0.0
	Granero	Y	904.9	840.5	32	120.0	437.5	279.0	4.0	6.2	4.0	1.9	0.3	6.2	2.2	13.0	53.0	0.8
	Ranchero	Y	998.3	915.0	30	183.2	419.1	300.5	12.2	5.8	3.7	2.1	0.0	23.2	2.4	21.0	63.0	0.2
	Sabroso	Y	477.9	430.2	54	1.0	51.1	361.4	16.8	7.7	5.1	2.6	0.0	4.2	6.8	34.0	79.0	0.0
	Tango	R	542.2	421.6		0.0	20.3	376.8	24.6	13.5	10.3	3.1	0.0	40.5	6.9	64.0	99.0	0.0
	Tesoro	Y	888.1	746.6	31	16.6	227.5	485.0	17.5	8.5	7.3	0.9	0.3	59.8	6.9	39.0	74.0	0.6
	Torero	Y	1066.9	929.8	31	219.5	478.3	226.1	5.9	10.2	7.4	2.7	0.1	24.9	2.5	14.0	61.0	0.0
	Valiant	Y	740.4	613.8	37	26.9	253.8	319.6	13.5	14.4	8.0	5.9	0.4	16.2	1.5	34.0	80.5	1.8
	Vaquero	Y	980.7	909.0	24	130.9	454.8	314.2	9.1	6.3	5.2	1.1	0.0	3.4	1.3	17.0	59.0	0.0
Mean			851.1	689.3	34.3	99.4	258.1	318.6	13.2	10.9	8.6	2.3	0.1	65.7	3.6	28.6	64.6	0.5
LSD (0.05)			137.4	130.4	5.0	137.3	60.8	89.3	10.6	7.7	6.9	2.2	NS	28.6	5.4	6.8	7.3	1.1

EFFECTS OF ONION PLANT DAMAGE AND FIELD HEAT STRESS ON TRANSLUCENT SCALE IN ONION BULBS

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Introduction

Onion translucent scale is a physiological disorder in which the bulb scales or rings acquire a translucent or watery appearance. Causes of translucent scale remain unknown. Research has shown that field curing and artificial drying can be associated with translucent scale (Solberg and Boe 1997). The objective of this trial was to elucidate the influence of plant top damage and temperature in the field on translucent scale development in the Treasure Valley of Oregon and Idaho. The effects of temperature were investigated prior to lifting and during curing.

Methods

The procedures for the cultural practices for growing the onion crop can be found in the following report "Effects of heating and freezing on translucent scale in onion bulbs" in the section "Procedures for field 2."

Procedures for Heat Treatments

The field was divided into 20 plots that were 30 ft long and 4 rows wide. Each plot was allocated to one of four treatments (Table 1) consisting of foliar damage and attempts at enhancing solar heating of the soil surface and onion bulbs in mid-August. On August 13 one-half of the total height of foliage was cut and removed from the foliar damage plots. On August 14, transparent plastic was laid between the onion double rows in the heated soil plots. Temperature sensors (TMC20-HA, Onset Computer Corp., Bourne, MA) were installed in each plot center at 0.4 inch depth and approximately 1 inch from the onion row. Temperature sensors were connected to HOBO H8 4-channel dataloggers (Onset Computer Corp., Bourne, MA) and read every hour. On August 20, the plastic was removed from the plots.

Table 1. Treatments applied to onions in August, 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Plastic mulch	Leaf damage
1 (check)	none	none
2	yes	none
3	yes	yes
4	none	yes

On September 11 the onions were lifted to field cure. Also on September 11, transparent plastic was laid over half (15 ft) of each plot, resulting in 40 subplots. The plastic was laid as a continuous sheet, covering all the onions. Temperature sensors were installed in each plot half on the soil surface. Temperature sensors were connected to HOBO H8 4-channel dataloggers and read every hour. On September 13, the plastic was removed from the plots.

On September 18, onions from the middle two double rows in each subplot were topped and bagged. The bags were placed into storage on September 21. The storage shed was managed to maintain an air temperature of approximately 34°F. The bulbs from each subplot were divided into six sample bags. The bags were weighed and placed into storage. One bag from each subplot is being weighed and evaluated monthly for loss of weight and the occurrence of translucent scale. Each bulb is cut equatorially and checked for translucent scale. The number and location of translucent scales in each bulb is recorded.

Results and Discussion

Onions grew well, yielding 965 cwt/acre. The temperature treatments applied in mid-August prior to onion lifting did not significantly increase the soil temperature at 0.4-inch depth (Table 2). The temperature treatments applied in mid-September after lifting also did not significantly increase the temperature on the soil surface (Table 3). The temperatures recorded for the untreated check were surprisingly high. The check treatment was subject to a total of 15 noncontinuous hours of soil temperatures above 115°F before lifting and to a total of 9 noncontinuous hours of air temperature above 115°F during curing.

The field-applied temperature treatments did not significantly increase the incidence of translucent scale, despite the high temperatures reached (Table 4). The percent of bulbs with translucent scale and the number of translucent scales per bulb increased significantly between December and January, independent of the treatments.

References

Solberg, S.O. and E. Boe. 1997. The influence of crop management on watery scales in onions - a survey in south-eastern Norway. In: Translucent and leathery scales in bulb onions (*Allium cepa* L.), Norwegian Crop Research Institute, Doctor Scientarum Theses 30.

Table 2. Temperature statistics for mid-August, 2001 field heat treatments. Temperature sensors were buried at 0.4-inch depth. Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Plastic mulch	Leaf damage	Maximum temperature, °F	Hours above 110°F	Hours above 115°F
1 (check)	none	none	118	23	15
2	yes	none	118	22	15
3	yes	yes	97	16	7
4	none	yes	111	14	9
LSD (0.05)			NS	NS	NS

Table 3. Temperature statistics for mid-September, 2001 post-lifting field heat treatments. Temperature sensors were located on the soil surface. Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	Plastic	Leaf damage	Maximum temperature, °F	Hours above 110°F	Hours above 115°F
1 (check)	none	none	116	14	9
2	none	yes	120	14	7
3	yes	none	124	13	10
4	yes	yes	123	6	5
LSD (0.05)			NS	NS	NS

Table 4. Effect of temperature treatment before lifting and during curing on onion translucent scale. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001-2002.

	Pre-lifting		Post-lifting	Percent of bulbs with translucent scales				Average number of translucent scales*				Average location of translucent scales†			
Treatment	Plastic mulch	Leaf damage	Plastic	Oct.	Nov.	Dec.	Jan.	Oct.	Nov.	Dec.	Jan.	Oct.	Nov.	Dec.	Jan.
1	yes	none	none	0.0	0.0	0.0	0.0								
2	yes	none	yes	0.0	0.0	2.7	3.2			2.3	3.7			7	5
3	yes	yes	none	1.0	1.2	0.0	7.1	1.0	2.0		3.3	1.0	4.5		5.5
4	yes	yes	yes	0.0	0.0	1.6	3.3			6.0	6.8			3.5	3.9
5	none	none	none	0.0	0.9	0.0	3.2		1.0		5.3		10		4.5
6	none	none	yes	0.0	0.0	0.8	5.7			5.0	4.2			4.8	2.6
7	none	yes	none	0.0	0.8	0.0	3.9		2.0		2.8		10.5		3.3
8	none	yes	yes	0.0	0.0	0.9	12.3			2.0	5.7			9.5	4.0
Mean				0.13	0.35	0.75	4.83	0.03	0.13	0.59	1.81	0.03	0.63	0.88	4.11
LSD (0.05) Treatment				NS	NS	NS	N	NS	NS	NS	NS	NS	NS	NS	NS
LSD (0.05) Month				2.41				0.87				NS			
LSD (0.05) Trt. X Month				NS				NS				NS			

*Average number of translucent scales in bulbs with translucent scales.

† Scale number counted from bulb outside.

EFFECTS OF HEATING AND FREEZING ON TRANSLUCENT SCALE IN ONION BULBS

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Introduction

Onion translucent scale is a physiological disorder in which the bulb scales or rings acquire a translucent or watery appearance. Causes of translucent scale remain unknown. Research has shown that field curing and artificial drying temperatures can be associated with translucent scale (Solberg and Boe 1997). The objective of this trial was to elucidate the influence of heating and freezing on translucent scale development in the Treasure Valley of Oregon and Idaho

Procedures

Onions were harvested for the temperature treatments from two fields.

Procedures for Field 1

The onions were grown on an Owyhee silt loam with 2.1 percent organic matter and a pH of 7.2. The field had previously been planted to wheat. In the fall of 2000, 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. Before plowing, 20 lb N/acre, 200 lb P_2O_5/acre, 28 lb K /acre, 150 lb S/acre, 28 lb Mg/acre, 10 lb Zn/acre, and 5 lb Cu/acre were broadcast.

Beds were knocked down March 21, 2001. On March 22, onion seed (cv. 'Ranchero', Sunseeds, Morgan Hill, CA) was planted at 150,000 plants per acre on beds spaced 22 inches apart. 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 25. The field was sidedressed with 100 lb N/acre, 10 lb Zn/acre, 1 lb Cu/acre, and 1 lb B/acre on May 21. On June 21, 100 lb N/acre was water run as urea ammonium nitrate solution (Uran).

The trial was managed to avoid yield reductions from weeds, pests, and diseases. Weeds were controlled with cultivations on May 20 and June 19, and with low-rate herbicide applications as needed until lay-by (Goal at 0.031 lb ai/acre, Buctril at 0.16 lb ai/acre, and Poast at 0.26 lb ai/acre on May 19 and Prowl at 0.83 lb ai/acre on May 30). After lay-by the field was hand weeded as necessary. Thrips were controlled with four aerial applications of Warrior and Lannate (June 30, July 20, August 1, and August 18) and one aerial application of Warrior on June 11. Warrior was applied at 0.03 lb ai/acre and Lannate was applied at 0.26 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. Inc., Riverside, CA) installed on June 7 below the onion row at 8-inch depth. Sensors were automatically read three times a day with an AM-400 meter (Mike Hansen, East Wenatchee, WA,). The last irrigation was on August 31.

The onions were lifted on September 10 to field dry. Onions were topped and bagged by hand on September 17. The onions were placed into storage on September 21.

Procedures for Field 2

The onions were grown at the Malheur Experiment Station, Ontario, Oregon on an Owyhee silt loam previously planted to wheat. This field has a record of moderate productivity, perhaps due to the removal of much of the topsoil decades in the past during land leveling. In the fall of 2000, 200 lb P_2O_5, 55 lb K, 150 lb S, 28 lb Mg, 10 lb Zn, and 5 lb Cu per acre were broadcast and the field was plowed and groundhogged twice. The field was fumigated on October 25 with Telone C-17 at 24 gal/acre and bedded on 22-inch centers. A soil sample taken from the top foot on May 16, 2001 showed a pH of 7.9, 0.6 percent organic matter, 4 ppm NO_3 -N, 47 ppm P, and 381 ppm K.

Onion seed (cv. 'Ranchero', Sunseeds, Morgan Hill, CA) was planted in two double rows, spaced 22 inches apart on 44-inch beds on March 30, 2001. Onion was planted at 210,000 seeds/acre. Drip tape was laid 4 inches deep in the bed center. The onions were hand thinned to a plant population of 100,000 plants per acre on May 17. Nitrogen fertilizer was applied through the drip tape as Uran at 30 lb N/acre on May 24, June 6, June 13, June 20, and July 3. Nelson Pathfinder tape (Nelson Irrigation Corp., Walla Walla, WA) was laid simultaneously with planting at 6-inch depth between the two double onion rows. The drip tape had emitters spaced 12 inches apart and a flow rate of 0.22 gal/min/100 ft.

Immediately after planting the onion rows received 3.7 oz of Lorsban 15G per 1,000 ft of row (0.82 lb ai/acre), and the soil surface was rolled. The trial was irrigated on April 9, April 17, April 24, April 27, and April 30 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. Onions started emerging on April 21.

The soil water potential at 8-inch depth was designed to be maintained nearly constant at -20 kPa by applying 0.06 acre-inch/acre of water up to eight times a day as needed based on automated soil water potential readings every 3 hours (Shock et al. 2000). The automated drip irrigation system was started on May 14.

Postemergence weed control was obtained by an application of Buctril (0.08 lb ai/acre) and Poast (0.19 lb ai/acre) on May 9, Goal (0.031 lb ai/acre), Buctril (0.16 lb ai/acre), Poast (0.26 lb ai/acre) and Prowl (0.83 lb ai/acre) on May 19, Goal (0.05 lb ai/acre) on

May 30, and Goal (0.12 lb ai/acre) on June 8. After lay-by the field was hand weeded as necessary. Thrips were controlled with four aerial applications of Warrior (0.03 lb ai/acre) and Lannate (0.26 lb ai/acre) on June 30, July 20, August 1, and August 18 and one aerial application of Warrior (0.03 lb ai/acre) on June 11.

On September 11 the onions were lifted to field cure. On September 18, onions from the middle two double rows in each subplot were topped and bagged. The bags were placed into storage on September 21. The storage shed was managed to maintain an air temperature of approximately 34°F.

Procedures for Heat Treatments

On October 2, the onions from each field were divided into seven lots and placed into crates. Each lot was submitted to one of seven temperature treatments. Temperature treatments were 30, 80, 90, 100, 110, 120°F. The heat treatments were achieved by placing the bulbs in a forced-air oven for 20 hours. The freezing treatment was achieved by placing the bulbs in a walk-in cooler with circulating air for 20 hours. Air and bulb temperatures during heating and cooling treatments were measured with temperature probes read by a datalogger (Hobo datalogger, Onset Computer Corp. Bourne, MA). The bulb temperature was measured at 0.08-, 0.4-, and 1.6-inch depth. A fourth probe measured bulb temperature in the bulb neck. The onions in each crate were weighed before and after the temperature treatments. After being treated the onions were divided into six lots. Each lot was divided into four bags (four replicates). The bags were weighed and placed into storage. Four bags from each lot were weighed and evaluated monthly for the occurrence of translucent scale. Each bulb was cut equatorially and checked for translucent scale. The number and location of translucent scales in each bulb was recorded.

Results and Discussion

Onions from both fields grew well and yields were 965 cwt/acre for the drip-irrigated field and 998 cwt/acre for the furrow-irrigated field. Onion bulbs had on average 10 to 12 scales per bulb. There was no significant difference between fields in the incidence of translucent scale in response to the treatments.

The forced-air oven treatments were effective in increasing the bulb temperature up to 1.6-inch depth in the onion (Fig. 1). The maximum bulb temperatures achieved for the heated onions generally were approximately the same as the intended temperature treatment (Table 1, Fig. 2). The minimum temperature achieved for the cold-treated bulbs was lower than the intended 30°F (Fig. 3).

The low temperature treatment (30°F) increased the incidence of translucent scale in October (Table 1). By November the incidence of translucent scale in the cold-treated bulbs was not significantly higher than in the untreated bulbs. The translucent scales in the cold-treated bulbs in October showed the translucence only in small round spots in the scales. The 30°F treatment showed a decrease in the percent of bulbs with translucent scale and the number of translucent scales per bulb from October to November.

The location of the translucent scales in the 30°F treatment shifted from the middle scales to the outer scales from October to November and again from December to January.

Only the highest forced-air oven treatment (120°F) resulted in an increase in the incidence of translucent scale. The translucent scales in the 120°F treated bulbs show the translucence continuously in the whole ring. The percent of bulbs with translucent scale increased significantly in the 120°F treatment from October to November. There was also a significant increase in the number of translucent scales per bulb from November to December for the 120°F treatment. The translucent scales in the bulbs subjected to 120°F were located in the middle scales.

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Solberg, S.O. and E. Boe. 1997. The influence of crop management on watery scales in onions - a survey in southeastern Norway. In: Translucent and leathery scales in bulb onions (*Allium cepa* L.), Norwegian Crop Research Institute, Doctor Scientarum Theses 30.

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

Table 1. Effect of temperature treatment of onion bulbs in a forced air oven for 20 hours on onion translucent scale. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001-2002.

Temperature treatment, °F	Maximum or minimum temperature achieved, °F	Percent of bulbs with translucent scales				Average number of translucent scales*				Average location of translucent scales†			
		Oct.	Nov.	Dec.	Jan.	Oct.	Nov.	Dec.	Jan.	Oct.	Nov.	Dec.	Jan.
30	22	57.5	10.0	12.5	7.5	6.4	1.3	4.7	3.7	6.3	4.5	4.9	2.7
Check		0.8	0.0	0.6	1.3	1.5		3.5	3.8	5.8		4.5	3.1
80	83	3.6	1.4	1.7	0.4	1.4	1.3	4.3	5.0	6.9	6.3	5.4	3.0
90	89	0.0	1.1	2.1	3.8		2.3	5.9	4.6		5.9	6.1	3.1
100	107	0.3	1.2	1.2	0.8	1.0	3.0	5.5	3.0	1.0	9.0	5.3	7.5
110	111	0.7	0.4	1.7	1.2	1.0	2.3	2.3	4.3	1.0	7.0	5.7	6.3
120	118	44.9	62.8	70.0	65.5	4.1	2.5	8.3	8.9	5.7	7.7	6.1	6.0
Mean		15.4	11.0	12.8	11.5	2.2	1.8	4.9	4.8	3.8	5.8	5.4	4.5
LSD (0.05) Trt		19.5	12.5	12.0	13.6	1.6	1.4	3.9	3.1	2.9	NS	NS	3.1
LSD (0.05) Month		5.4				0.91				NS			
LSD (0.05) Trt X Month		15.3				2.4				2.0			

*Average number of translucent scales in bulbs with translucent scales.
†Scale number counted from bulb outside.

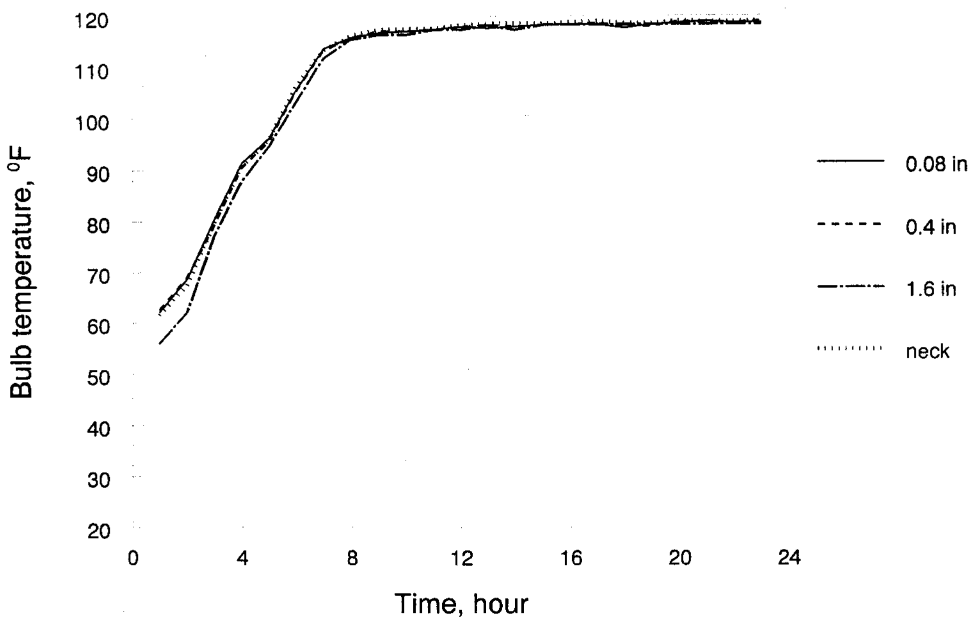

Figure 1. Onion bulb temperature at four depths over time for onions submitted to 120°F in a forced-air oven. Temperature data is based on the average of four replicate readings. Malheur Experiment Station, Oregon State University, Ontario, OR.

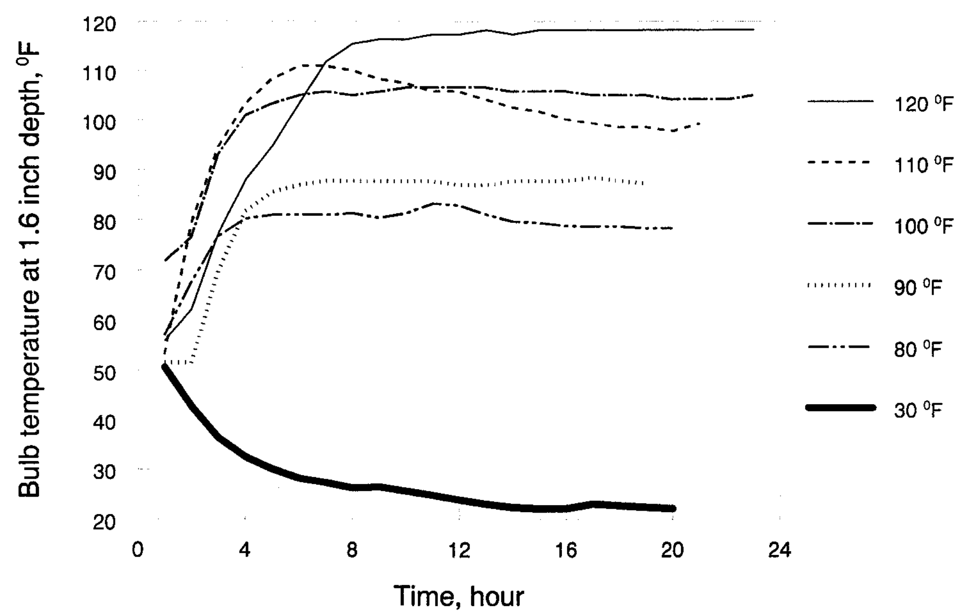

Figure 2. Onion bulb temperature at 1.6-inch depth over time for onions submitted to six temperature treatments in a forced-air oven. Temperature data is based on the average of four replicate readings. Malheur Experiment Station, Oregon State University, Ontario, OR.

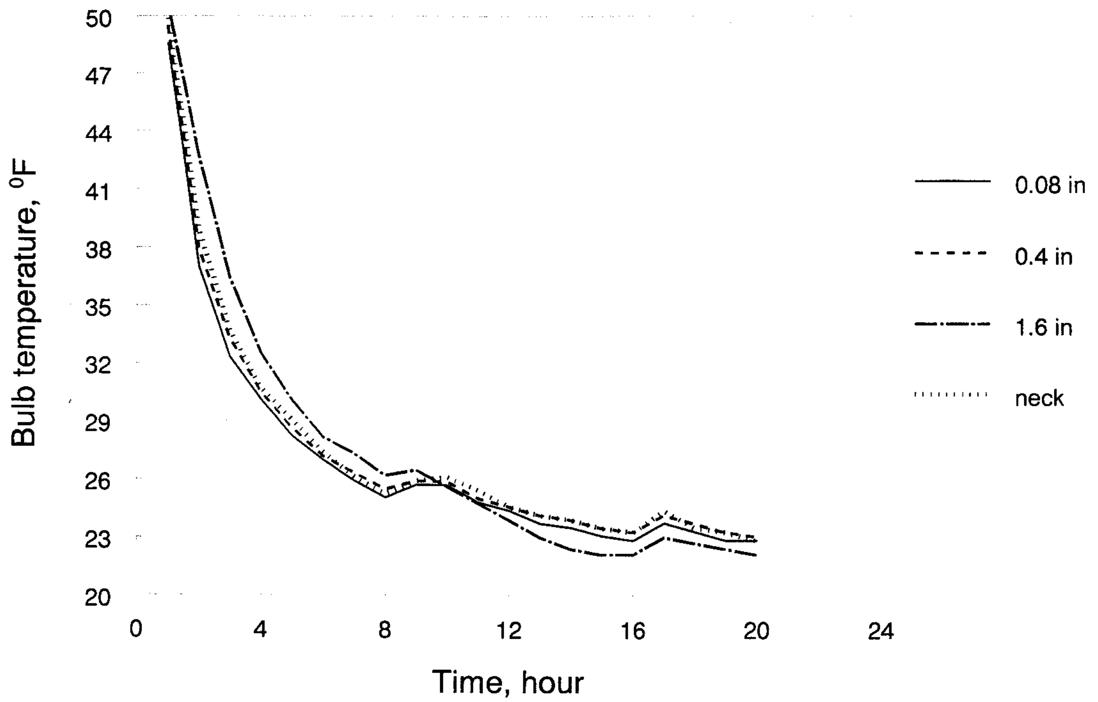

Figure 3. Onion bulb temperature at four depths over time for onions submitted to freezing. Temperature data is based on the average of four replicate readings. Malheur Experiment Station, Oregon State University, Ontario, OR.

PLANT POPULATION AND NITROGEN FERTILIZATION FOR SUBSURFACE DRIP-IRRIGATED ONIONS

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Summary

Onion yield and grade was tested in response to a combination of seven nitrogen fertilizer rates (0 to 300 lb N/acre) and four plant populations (75,000 to 139,000 plants/acre) under subsurface drip irrigation on Owyhee silt loam. Onion was planted on two double rows on 44-inch beds with one drip tape in the bed center. All treatments were irrigated automatically with 0.06 inches of water up to eight times a day. Irrigations were started when the soil water potential reached -20 kPa at 8-inch depth. The N fertilizer was applied through the drip tape. Onion yield and grade were not responsive to N rate in this trial. The unfertilized check treatment in this trial had a total N supply of 303 lb/acre in the top 2 ft of soil during the season, counting the initial residual soil nitrate and ammonium, mineralized N, and nitrate and ammonium in the irrigation water.

Total marketable yield increased with increasing plant population up to 109,000 plants per acre. The highest supercolossal and colossal onion yields were achieved with the lowest plant population tested of 79,000 plants per acre. In 1999 supercolossal yield was not measured, and gross returns increased with increasing plant population. In 2000 and 2001, with supercolossal yield being taken into account, onion gross returns did not show a response to plant population. Within the range of plant populations tested in this study, increasing or decreasing the plant population did not affect the gross returns when supercolossal onions were included.

Introduction

Onion production with subsurface drip irrigation has been tested at the Malheur Experiment Station since 1992. While good guidelines for irrigation scheduling are known, the optimum N fertilization practices for subsurface drip-irrigated onions are unknown. The plant population that optimizes yield and size of onions could be different under drip irrigation and could interact with the N fertilizer rate.

Residual soil N and fertilizer N have the potential to be used more efficiently when applied through drip irrigation than when applied broadcast, sidedressed, or water run in a furrow irrigated field. Nitrogen applications with drip irrigation might be reduced compared to furrow irrigation as a result of the lower N leaching and the higher N use efficiency.

The objective of this trial was to determine the optimum N rate and plant population combination for drip-irrigated onions to maximize yield, quality, and economic return.

Materials and Methods

The trial was conducted at the Malheur Experiment Station, Ontario, Oregon on an Owyhee silt loam previously planted to wheat. This field has a record of moderate productivity, perhaps due to the removal of much of the topsoil decades in the past during land leveling. In the fall of 2000, 200 lb P_2O_5, 55 lb K, 150 lb S, 28 lb Mg, 10 lb Zn, and 5 lb Cu per acre were broadcast and the field was plowed and groundhogged twice. The field was fumigated on October 25 with Telone C-17 at 24 gal/acre and bedded on 22-inch centers. A soil sample taken from the top foot on May 16, 2001 showed a pH of 7.9, 0.6 percent organic matter, 4 ppm NO_3 -N, 47 ppm P, and 381 ppm K. Onions (cv. 'Vision', Petoseed, Payette, ID) were planted in two double rows, spaced 22 inches apart in 44-inch beds on March 30, 2001. Onions were planted at 210,000 seeds/acre. Nelson Pathfinder tape (Nelson Irrigation Corp., Walla Walla, WA) was laid simultaneously with planting at 4-inch depth between the two double onion rows. The drip tape had emitters spaced 12 inches apart and a flow rate of 0.22 gal/min/100 ft. Immediately after planting the onion rows received 3.7 oz of Lorsban 15G per 1,000 ft of row (0.82 lb ai/acre), and the soil surface was rolled. The trial was irrigated on April 9, April 17, April 24, April 27, and April 30 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. Onions started emerging on April 21.

The seven N rates ranged from 0 to 300 lb N/acre (0, 50, 100, 150, 200, 250, 300 lb N/acre). The nitrogen for each treatment was split into five equal amounts. The N fertilizer was applied as urea-ammonium nitrate (Uran) on May 24, June 4, June 14, June 26, and July 3. Fertilizer solutions were applied through the drip lines with venturi injector units (Mazzei injector Model 287) installed in each plot. Nitrogen treatments were the main plots and were replicated three times. Nitrogen treatments were arranged in a randomized complete block design. Plant populations were split plots within each N plot. The plant populations (75,000, 100,000, 125,000, and 150,000 plants per acre) were achieved by hand thinning on May 17. Individual population plots were two beds wide and 50 ft long.

The soil water potential at 8-inch depth was designed to be maintained nearly constant at -20 kPa by applying 0.06 acre-in/acre of water up to eight times a day as needed based on automated soil water potential readings every 3 hours (Shock et al. 2000). The automated drip irrigation system was started on May 14.

Soil water potential (SWP) was measured with one granular matrix sensor (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co. Inc., Riverside, CA) at 8-inch depth, below an onion row in each split plot. In addition each main plot had a GMS installed at 18-inch depth below an onion row in the 125,000 plants/acre split plot. Sensors were calibrated to SWP (Shock et al. 1998). The GMS were connected to a datalogger (CR 10 datalogger, Campbell Scientific, Logan, UT) via five multiplexers (AM 410 multiplexer, Campbell Scientific, Logan, UT). The datalogger was programmed to read the GMS every 3 hours and, if the average of the sensors at 8-inch depth was less than -20 kPa, irrigate the field. The irrigations were controlled by the datalogger using a solenoid valve. The pressure in the drip lines was maintained at 10 psi by pressure regulators in each main plot. The amount of water applied to the field was recorded daily at 8:00 a.m. from a water meter installed downstream of the solenoid valve.

Onion evapotranspiration (Et_c) was calculated with a modified Penman equation using data collected at the Malheur Experiment Station by an AgriMet weather station (Wright 1982). Onion Et_c was estimated and recorded from crop emergence on April 21 until the final irrigation on September 5 and compared with evapotranspiration.

Ten plants from the border rows in each 125,000 plants/acre subplot were sampled for nutrient analyses every 2 weeks from early June through mid August. The plants were washed, the roots were analyzed for nitrate-N, phosphate-P, K, and sulfate-S, and the leaves were analyzed for micronutrients by Tremblay Consulting of Jerome, Idaho. The root nitrate levels for each N rate were compared to a critical level for onion root nitrate (Brown and Hornbacher 1988).

Postemergence weed control was obtained by an application of Buctril (0.08 lb ai/acre) and Poast (0.19 lb ai/acre) on May 9, Goal (0.031 lb ai/acre), Buctril (0.16 lb ai/acre), Poast (0.26 lb ai/acre) and Prowl (0.83 lb ai/acre) on May 19, Goal (0.05 lb ai/acre) on May 30, and Goal (0.12 lb ai/acre) on June 8. After lay-by the field was hand weeded as necessary. Thrips were controlled with four aerial applications of Warrior (0.03 lb ai/acre) and Lannate (0.26 lb ai/acre) on June 30, July 20, August 1, and August 18 and one aerial application of Warrior (0.03 lb ai/acre) on June 11.

On August 23, ten onion plants from the border rows in each subplot were taken for total N content determination. The tops were weighed, dried, weighed and ground. The bulbs were weighed and shredded. A shredded bulb subsample was weighed, dried, weighed, and ground. The ground top and bulb samples were analyzed for total N content. Nitrogen contribution from organic matter mineralization was estimated by anaerobic incubation at 104°F for 7 days. The well water used for irrigation was analyzed for NO_3-N and NH_4-N on June 29, and August 23. The well water used for irrigation had an average NO_3 and NH_4 concentration of 10.4 ppm and 1 ppm, respectively. Nitrogen contribution from irrigation was calculated to be 2.37 lb N/acre per acre-in of water. The soil was sampled in 1-ft increments down to 2 ft in each replicate before planting and in each 125,000 plants/acre subplot after harvest and analyzed for nitrate and ammonium.

On September 11 the onions were lifted to field cure. On September 18, 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 21. The storage shed was managed to maintain an air temperature of approximately 34°F. The onions were graded out of storage in mid-December. Bulbs were graded according to their diameters: small (<2¼ inches), medium (2¼ -3 inches), jumbo (3-4 inches), colossal, (4-4¼ inches), and supercolossal (>4¼ inches). Bulb counts of supercolossal onions were made during grading. Split bulbs were graded as No. 2s regardless of diameter. Marketable onions were considered perfect bulbs in the medium, jumbo, colossal and supercolossal size classes. Bulbs from all subplots were counted during grading in order to determine the actual plant population at harvest.

Gross economic returns were calculated by crediting the onion size classes with the average of prices paid to the grower (F.O.B. prices minus $3.13/50 lb for packing cost) from early August through January for the years 1992 through 2001.

Results and Discussion

Water applications over time closely followed, but were slightly higher than onion Et_c (Fig. 1). Onion Et_c for the 2001 season totaled 32 acre-inch/acre and irrigation water applied plus precipitation totaled 38 acre-inch/acre. Precipitation totaled 1.4 inches from onion emergence to the last irrigation. The field used for the 2001 study required slightly more water to keep the sensors at -20 kPa than the 2000 field. Soil water potential at 8-inch depth remained close to -20 kPa (Fig. 2), except for brief periods due to technical problems with the automated irrigation system. Soil water potential at 20-inch depth remained close to soil water potential at 8-inch depth.

Onion yield and grade did not respond to N rate (Table 1). There were 171 lb/acre of NO_3-N and NH_4-N in the top 2 ft of soil on May 15 (Table 2). A total of 45 lb/acre of NO_3-N and NH_4-N were released in the top 2 ft of soil from N mineralization. The unfertilized check treatment in this trial had a total N supply of 236 lb/acre in the top 2 ft of soil during the season, counting the initial residual soil nitrate and ammonium, mineralized N, and nitrate and ammonium in the irrigation water.

Onion root nitrate during most of the season remained close to or above the established nitrate "critical" level only for the four highest N rates (150, 200, 250, and 300 lb N/acre; Fig. 3). Onions with root nitrate below the "critical level" supposedly need more N to optimize yield. For the other N rates onion root nitrate remained below the critical level during most of the season. The N fertilizer in this trial was applied in small increments as opposed to conventional sidedressing of N. Under low leaching conditions, sources of N other than fertilizer can make significant contributions to the N supply for onions. When the onion plants receive N in small increments, root nitrate levels might remain low despite the plant having adequate N. The lack of onion yield response to N in this trial was inconsistent with the root nitrate critical line. These results cast doubt on the accuracy of the critical root nitrate function for drip-irrigated onions.

Onion populations of 125,000 and 150,000 plants per acre were not achieved (Table 1). The highest total yield and jumbo onion yield were achieved with the highest plant population tested of 127,000 plants per acre (Table 1). Total marketable yield increased with increasing plant population up to 109,000 plants per acre. The highest supercolossal and colossal onion yield were achieved with the lowest plant population tested of 79,000 plants per acre. All plant populations resulted in numbers of supercolossal bulbs per 50 lb of supercolossal bulbs, which were within the acceptable range (28-36 count per 50 lb) for marketing as supercolossal. Gross financial returns were not responsive to plant population in 2001, within the populations tested.

Regressions for onion yield in response to plant population show that medium and jumbo onion yield increased whereas colossal and supercolossal onion yield decreased with increasing plant population (Fig. 4). This is the third and final year of this trial. In 1999 supercolossal yield was not measured, and gross returns increased with increasing plant population (Fig. 5). In 2000 and 2001, with supercolossal yield being taken into account, onion gross returns were not responsive to plant population. Within the range of plant populations tested in this study, increasing or decreasing the plant population did not affect the gross returns when supercolossal onions were included.

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Table 1. Onion yield and grade response to N rate and plant population after 2½ months of storage. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Target plant population	N rate	Harvested bulbs	Total yield	Marketable yield by grade						Non-marketable yield			Gross returns
				Total	>4¼ in	>4¼ in	4-4¼ in	3-4 in	2¼-3 in	Rot	No. 2	Small	
plants/acre	lb/acre	bulbs/acre	-- cwt/acre --		#/50 lb	---------- cwt/acre ----------				%	- cwt/acre -		$/acre
75,000	0	87,514	882.0	823.0	34.6	78.8	317.9	408.0	18.2	5.2	10.6	5.2	5,667
	50	81,673	835.4	801.1	33.5	56.5	310.4	420.0	14.3	2.3	10.5	3.9	5,414
	100	75,832	858.8	779.9	32.9	134.4	339.7	292.3	13.6	6.2	24.3	1.8	5,845
	150	76,327	875.7	785.7	32.6	124.0	377.7	271.3	12.7	7.1	24.5	3.0	5,941
	200	80,980	909.2	831.9	33.3	110.4	412.5	300.0	8.9	5.8	22.6	1.9	6,224
	250	72,466	829.2	765.7	32.6	126.8	345.1	289.0	4.8	4.1	30.2	0.0	5,770
	300	76,822	892.0	841.7	33.5	136.7	400.0	296.1	8.8	3.9	14.0	2.3	6,384
Average		78,802	868.9	804.1	33.3	109.6	357.6	325.2	11.6	4.9	19.5	2.6	5,892
100,000	0	96,028	921.9	850.2	36.8	24.1	292.6	517.2	16.3	6.0	12.8	2.8	5,418
	50	101,869	958.2	922.4	35.8	50.4	300.0	549.5	22.4	2.2	9.5	5.1	5,948
	100	98,602	969.5	931.8	35.0	58.2	342.6	513.7	17.4	2.3	11.0	5.0	6,192
	150	104,146	953.7	872.6	35.2	55.8	238.9	562.4	15.4	6.9	14.1	4.3	5,544
	200	91,078	935.3	883.4	34.5	83.5	376.1	411.9	12.0	4.6	7.4	1.5	6,210
	250	101,176	942.3	883.5	39.2	31.1	247.3	591.0	14.1	4.2	12.2	6.0	5,490
	300	99,691	973.2	900.1	35.3	62.0	308.8	515.9	13.4	6.2	10.5	3.4	5,952
Average		98,941	950.6	892.0	36.0	52.2	300.9	523.1	15.9	4.6	11.1	4.0	5,822
125,000	0	103,849	935.3	870.4	35.2	43.7	249.7	552.2	24.8	5.0	11.0	7.0	5,472
	50	111,076	970.1	947.2	36.9	36.2	246.5	630.7	33.8	1.5	1.5	7.2	5,791
	100	116,322	1050.2	976.1	37.1	34.7	286.9	625.3	29.2	5.0	14.7	7.7	6,074
	150	103,849	967.0	914.0	37.1	38.7	284.2	570.3	20.8	3.8	11.5	3.5	5,791
	200	110,878	1060.8	1021.4	39.4	46.1	337.2	621.5	16.5	1.7	16.0	5.4	6,569
	250	109,096	1022.1	973.7	37.4	43.4	322.3	586.9	21.1	2.0	22.1	5.6	6,248
	300	106,324	1026.4	976.9	35.0	52.5	327.0	579.6	17.8	3.3	12.3	3.4	6,341
Average		108,770	1004.6	954.2	36.9	42.2	293.4	595.2	23.4	3.2	12.8	5.7	6,041
150,000	0	138,696	1009.1	983.0	44.2	6.8	87.2	819.3	69.7	1.2	4.6	9.7	5,195
	50	123,054	959.8	934.9	40.3	11.1	158.3	710.1	55.4	1.4	2.6	8.6	5,240
	100	128,202	1082.9	1034.8	38.5	23.6	214.2	763.4	33.6	2.9	9.1	7.4	6,066
	150	133,350	997.3	915.6	42.9	14.4	136.1	716.7	48.4	6.7	3.9	7.0	5,107
	200	122,262	1045.4	1009.1	39.0	17.3	235.9	720.9	34.9	1.6	10.5	8.5	5,964
	250	129,390	1101.8	1063.1	38.9	28.0	206.6	796.1	32.5	2.0	10.2	6.7	6,216
	300	117,906	1036.0	966.6	36.5	28.2	238.8	674.8	24.7	4.9	11.9	5.2	5,845
Average		127,552	1033.2	986.7	40.0	18.5	182.4	743.0	42.8	3.0	7.5	7.6	5,662
LSD (0.05) N rate		NS	NS	NS	NS	NS	48.2	NS	10.5	NS	NS	NS	NS
LSD (0.05) Popul.		5559	28.5	37.5	1.6	16.8	36.4	43.8	7.9	NS	4.7	2.1	NS
LSD (0.05) N X Pop		NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2. Nitrogen supply for the upper 2 ft of soil for drip-irrigated onions with seven N rates in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

N rate	N supply				
	Pre-plant soil $NO_3 + NH_4$-N	Fertilizer N	N in irrigation water	Estimated N mineralization	Total N supply
	------------------------------- lb/acre -------------------------------				
0	170.8	0	86.7	45.3	302.8
50	170.8	50	86.7	45.3	352.8
100	170.8	100	86.7	45.3	402.8
150	170.8	150	86.7	45.3	452.8
200	170.8	200	86.7	45.3	502.8
250	170.8	250	86.7	45.3	552.8
300	170.8	300	86.7	45.3	602.8

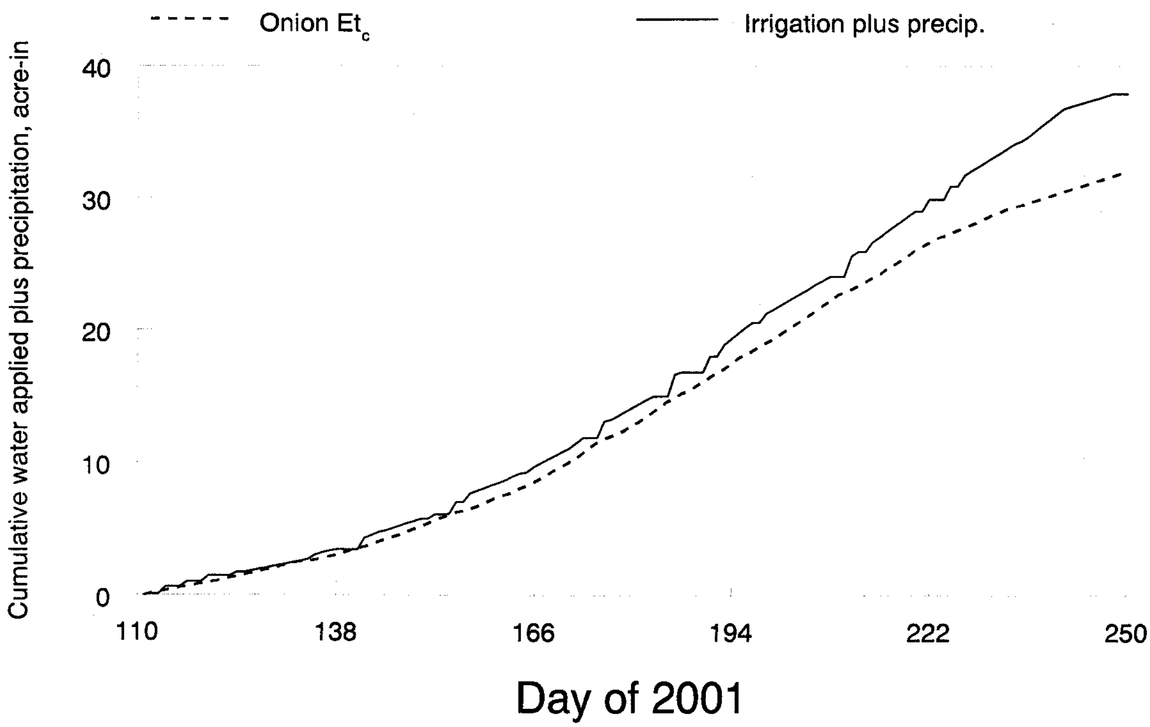

Figure 1. Cumulative water applied plus precipitation and Et_c for onions drip-irrigated at a soil water potential of -20 kPa compared with estimated onion evapotranspiration in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

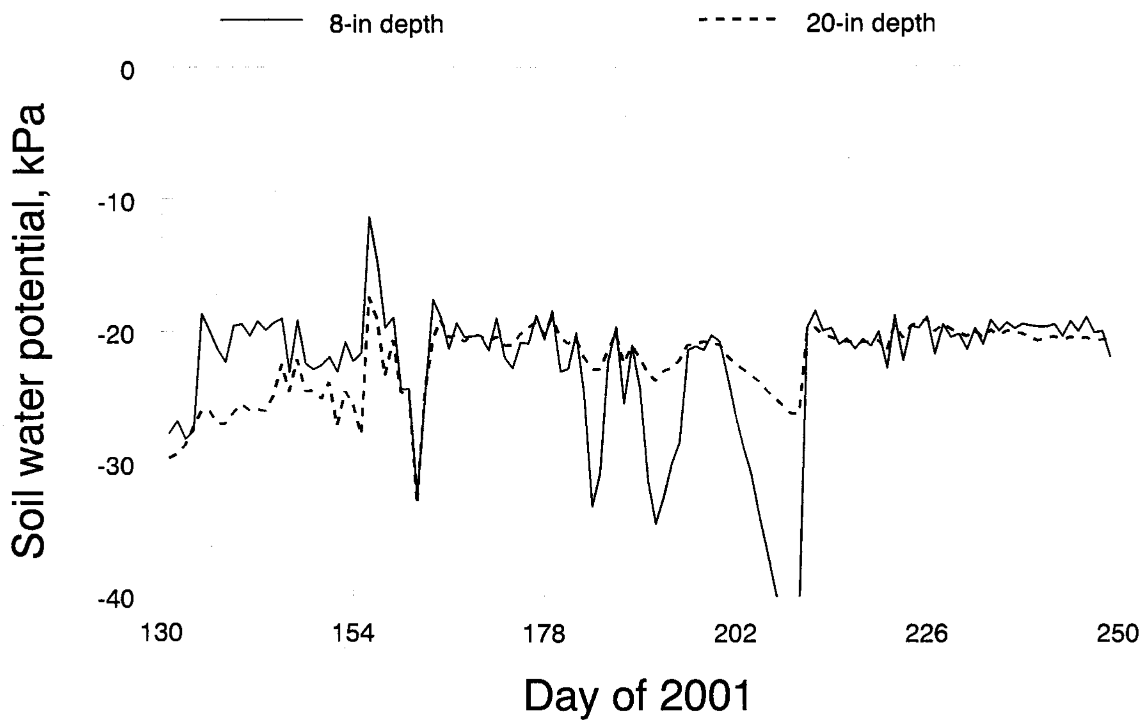

Figure 2. Soil water potential for drip-irrigated onions in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

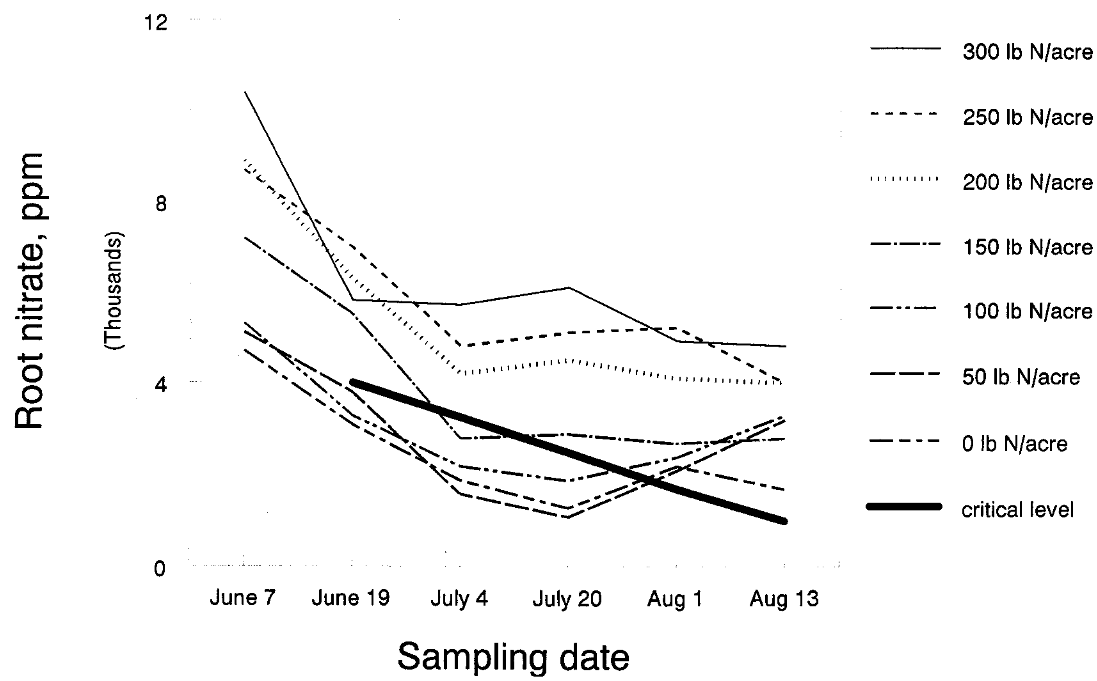

Figure 3. Onion root nitrate response to seven N rates applied through drip irrigation for onions at a plant population averaging 106,000 plants per acre in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

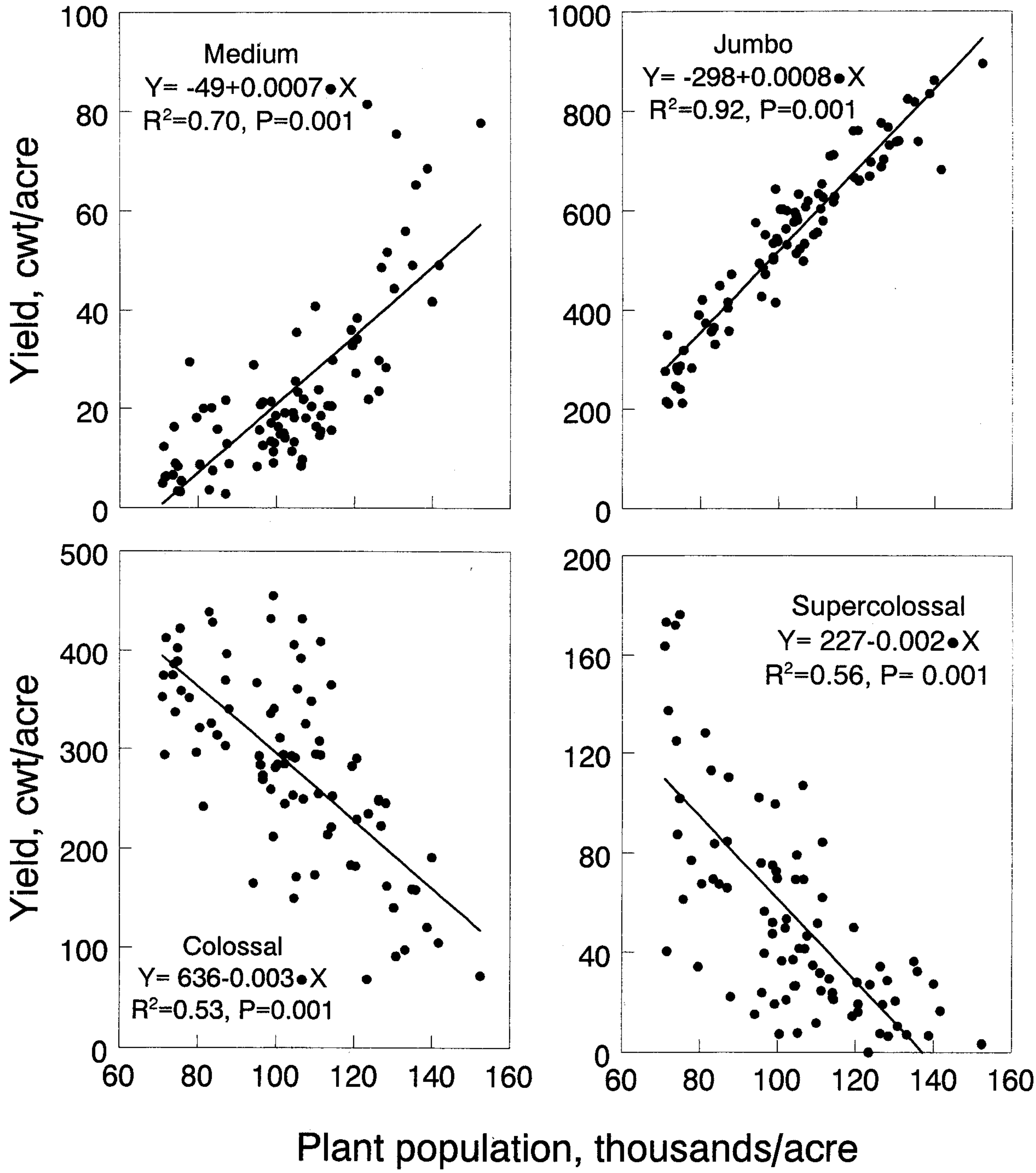

Figure 4. Onion yield response to plant population in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

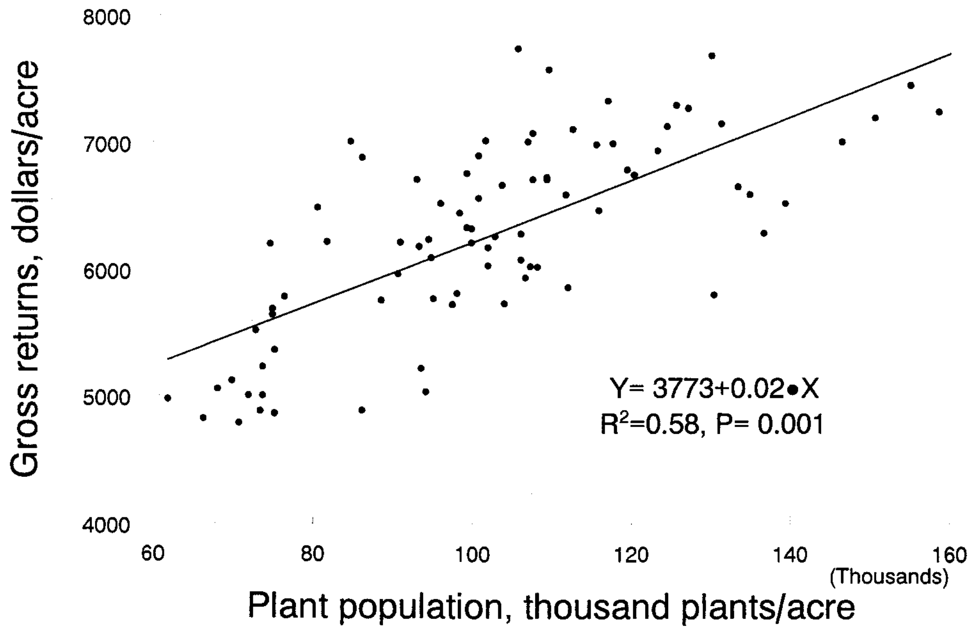

Figure 5. Onion gross return response to plant population in 1999. Malheur Experiment Station, Oregon State University, Ontario, OR.

WEED CONTROL AND ONION TOLERANCE WITH SOIL ACTIVE AND 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. Often combinations of postemergence and soil-active herbicides are required to improve overall weed control. Weed control research is important in identifying potential herbicides and management strategies to improve weed control in onions.

Methods

General Procedures

Trials were conducted at the Malheur Experiment Station to evaluate experimental and registered herbicides, and postemergence urea ammonium nitrate (32 percent N) solution applications for weed control and onion tolerance. The effect of spray volume on weed control and onion tolerance was also evaluated. Trials were conducted under furrow irrigation. All herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi.

On March 29, onions (cv. 'Vision', Petoseed, Payette, 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 three or 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 150 lb N/acre as urea on May 23. Registered insecticides and fungicides were applied for thrips and downy mildew control. Weed control and onion injury were evaluated throughout the season. Onions were harvested September 18 and graded by size on September 19 and 20.

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).

Soil-Active Herbicides for Weed Control in Onions

The soil-active herbicides Prowl, Dacthal, Dual Magnum, and Outlook were evaluated for crop injury and weed control applied either preemergence, to two-leaf onions, or as a lay-by treatment. Preemergence applications of Roundup (0.375 lb ai/acre) plus Prowl (0.75 or 1.0 lb ai/acre) or Dacthal (8.0 or 10.0 lb ai/acre) followed by sequential postemergence herbicide applications were compared to treatments where Prowl, Dacthal, Dual Magnum, and Outlook were applied in combination with the postemergence herbicides or as a lay-by application. In several treatments Prowl (0.63 or 1.0 lb ai/acre) was applied to flag leaf onions instead of preemergence with Roundup. Postemergence treatments of Buctril (0.15 lb ai/acre) plus Poast (0.1 lb ai/acre) were applied on May 19 to two-leaf onions, followed by Buctril (0.25 lb ai/acre) and Goal (0.125 lb ai/acre) applied on May 31 to four-leaf onions. Dacthal (6.0 lb ai/acre), Outlook (0.64, 0.33, 0.66 lb ai/acre), and Prowl (0.63 lb ai/acre) were added to the two-leaf application in several treatments to compare residual control with these products at various rates in combination with the postemergence herbicides. Lay-by treatments applied on June 15 consisted of Goal (0.25 or 0.125 lb ai/acre) alone or in combination with Prowl (0.75 lb ai/acre), Dacthal (6, 8, or 12 lb ai/acre), Dual Magnum (1.3 lb ai/acre), or Outlook (0.33, 0.64 lb ai/acre).

Onion Tolerance to Valor Combinations
Onions were evaluated for tolerance to postemergence applications of Valor herbicide. All plots received Roundup (0.375 lb ai/acre) preemergence on April 17 and Select (0.125 lb ai/acre) applied postemergence on May 18. Treatments applied May 19 to two-leaf onions included Valor (0.063, 0.094, or 0.125 lb ai/acre) applied either with a non-ionic surfactant (NIS) (0.25 percent v/v) or Buctril (0.15 lb ai/acre), Goal (0.125 lb ai/acre), and Goal plus Buctril. On June 15, Valor or Goal were applied to six-leaf onions. Plots were hand weeded on June 1, July 5 and 16, and August 7 to eliminate competition from escaped weeds.

Weed Control with Postemergence Nitrogen Applications
A trial was conducted to evaluate weed control from postemergence 32 percent N applications in onions. Treatments consisted of 32 percent N applied in a separate application as part of a postemergence herbicide program. Thirty-two percent N was applied at 20 or 30 gal/acre to flag leaf or one-leaf onions on April 26 or May 7, respectively. Treatments using preemergence applications of either Roundup (0.375 lb ai/acre) plus Prowl (1.0 lb ai/acre) or Roundup plus Dacthal (8.0 lb ai/acre) were applied on April 16. Following 32 percent N application, various combinations of Buctril (0.05, 0.15, or 0.25 lb ai/acre), Poast (0.1 lb ai/acre), and Goal (0.125 or 0.25 lb ai/acre) were applied to onions beginning at the two-leaf stage with final application at the six-leaf stage.

Spray Volume Effects on Weed Control and Onion Injury
Weed control and onion injury were evaluated with postemergence applications of Buctril and/or Goal at various rates and with spray volumes of 35 or 100 gal/acre. Treatments included Goal at 0.125 and 0.25 lb ai/acre in both 35 and 100 gal/acre spray volumes. Other treatments were Buctril (0.25 lb ai/acre) applied at both spray volumes; Buctril plus Goal (0.25 lb ai/acre) applied in 100 gal/acre spray volume; and an untreated check. All treatments were applied twice, with the first application made to two-leaf onions (May 19) and the second application applied to four-leaf onions (May 31). The entire experimental area received Roundup (0.375 lb ai/acre) applied preemergence on April 17 and Select (0.125 lb ai/acre) plus crop oil concentrate (1 percent v/v) on May 18. Weed and onion biomass samples were collected from 5-ft

sections of the second row in each plot on July 16. These samples were used to evaluate weed competition effect on onion yield.

Results and Discussion

Soil-Active Herbicides for Weed Control in Onions

All treated plots exhibited injury (7 to 28 percent on May 24 and 13 to 18 percent on June 27) (Table 1). Injury was greatest on May 24 in plots receiving postemergence applications including Buctril applied to two-leaf onions followed by Buctril plus Goal applied to four-leaf onions. Treatments including preemergence and lay-by applications of Prowl or Dacthal provided similar control of redroot pigweed, common lambsquarters, and hairy nightshade (Table 1). The split application of Dacthal (6.0 lb ai/acre) applied at the two-leaf timing and as a lay-by provided greater hairy nightshade control compared to Dacthal (12.0 lb ai/acre) applied only as a lay-by. Dacthal (6.0 lb ai/acre) applied to two-leaf onions and as a lay-by provided greater control of redroot pigweed than Dacthal (8.0 lb ai/acre) preemergence in combination with Dual Magnum or Outlook applied as a lay-by. All treatments gave 90 percent or better control of common lambsquarters; however, Dual Magnum lay-by gave significantly better control of common lambsquarters than did Outlook. Outlook plus Buctril (0.15 lb ai/acre) applied at the two-leaf timing increased hairy nightshade control over Outlook alone and Outlook plus Goal applied to two-leaf onions. Small onion yields were similar among treatments and were greatest for the untreated check (Table 1). Medium onion yields were not significantly different among treatments. In general, plots receiving soil-active herbicide applications included with Buctril plus Poast at the two-leaf application timing produced the greatest onion yields in terms of jumbo, colossal, and total onion yield (Table 1).

Onion Tolerance to Valor Combinations

On May 24, 5 days after the two-leaf application, injury associated with herbicide treatment was significantly greater than the untreated check (Table 2). Crop injury associated with Valor plus NIS treatments ranged from 44 to 49 percent and were similar regardless of application rate. Valor plus NIS produced significantly greater crop injury than all other treatments on May 24. Twelve days after the six-leaf application (June 27) all treatments except Valor (0.063 lb ai/acre) plus Buctril caused significant injury (5 to 11 percent). Injury was not significant for any treatment on July 11. Despite substantial early season injury, onion yields were not different among treatments (Table 2). Although the experimental data show no differences in onion yield, the visual injury associated with Valor treatment was not commercially acceptable.

Weed Control with Postemergence Nitrogen Applications

Late season (September 11) redroot pigweed, common lambsquarters, and hairy nightshade control were highest when Roundup plus Prowl were followed by Buctril (0.05 lb ai/acre) applied to one-leaf onions (Table 3). Total postemergence treatments including 32 percent N provided similar weed control regardless of the number of 32 percent N applications or the application rate. In plots receiving postemergence treatments only, Buctril (0.05 lb ai/acre) applied at the one-leaf timing provided greater hairy nightshade control at both evaluation dates than 32 percent N applied at the same timing. Onion injury from 32 percent N and/or herbicide treatment was higher than the untreated check 5 days after two-leaf application (May 24) and 12 days after six-leaf application (June 27) (Table 4). There were only slight differences in injury among treatments ranging from 13 to 20 percent on May 24 and 13 to 19 percent on June 27. Small and medium onion yields were highest among the untreated plots and those receiving postemergence applications of 32 percent N at 30 gal/acre applied to one-leaf onions and split applications of 32 percent N at 20 gal/acre applied to flag leaf and one-leaf onions (Table 4). Jumbo onion yields were greatest in plots that received preemergence applications of Roundup plus Prowl with and without buctril applied to one-leaf onions, and those receiving Buctril at the one-leaf timing. Colossal as well as total onion yields were significantly higher with treatments including preemergence applications of Roundup plus Prowl.

Spray Volume Effects on Weed Control and Onion Injury
Onion injury associated with herbicide treatment was significantly greater than the untreated check 5 days after two-leaf application on May 24 (Table 5). Injury ranging from 12 to 26 percent was generally similar among treatments with the highest injury in plots treated with Goal (0.25 lb ai/acre) and Buctril plus Goal each applied in 100 gal/acre spray volume. On June 27, visible injury ranged from 0 to 9 percent and was observed in plots treated with Goal (0.25 lb ai/acre), Buctril (0.25 lb ai/acre) and Buctril plus Goal, all applied in 100 gal/acre spray volume. Redroot pigweed control on both evaluation dates was greatest with treatments including Goal at 0.25 lb ai/acre alone and in combination with Buctril and was not affected by spray volume. Goal applied at 0.25 lb ai/acre provided greater redroot pigweed control on July 17 compared to Goal at 0.125 lb ai/acre regardless of spray volume. Common lambsquarters control was greatest in plots receiving Buctril at 0.25 lb ai/acre and with the tank-mix of Buctril plus Goal (Table 5). Common lambsquarters control on July 11 with Buctril (0.25 lb ai/acre) was 93 percent when applied in 35 gal/acre spray volume compared to 70 percent applied in 100 gal/acre spray volume. Goal provided greater common lambsquarters control when applied at the higher rate regardless of spray volume. All treatments that included Buctril provided greater than 88 and 84 percent hairy nightshade control on June 27 and July 11, respectively (Table 5). Hairy nightshade control with Goal treatments ranged from 34 to 61 percent on June 27 and from 0 to 27 percent on July 11. Total dry weed biomass correlated well with total dry onion yield (Fig. 1).

Table 1. Onion injury, weed control, and yield response to soil-active herbicides, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Injury		Weed control†			Onion yield				
Treatment	Rate	Timing*	5-24	6-27	Redroot pigweed	Common lambsquarters	Hairy nightshade	Small	Medium	Jumbo	Colossal	Total
	lb ai/acre	Leaf	%					cwt/acre				
Untreated	--	--	0	0	0	0	0	34	0	0	0	34
Hand-Weeded	--	--	0	0	95	98	93	12	57	588	171	837
Roundup + Prowl Buctril + Poast Buctril + Goal Goal + Prowl	0.375 + 0.75 0.15 + 0.1 0.25 + 0.125 0.25 + 0.75	PRE 2-leaf 4-leaf Lay-by	23	17	68	100	72	10	49	634	120	818
Roundup + Dacthal Buctril + Poast Buctril + Goal Goal + Dacthal	0.375 + 8.0 0.15 + 0.1 0.25 + 0.125 0.25 + 8.0	PRE 2-leaf 4-leaf Lay-by	22	15	69	98	73	19	81	598	84	789
Roundup + Dacthal Buctril + Poast Buctril + Goal Goal + Dacthal	0.375 + 10.0 0.15 + 0.1 0.25 + 0.125 0.25 + 12.0	PRE 2-leaf 4-leaf Lay-by	28	15	76	96	73	14	89	669	61	839
Roundup + Prowl Buctril + Poast Buctril + Goal Goal + Dacthal	0.375 + 1.0 0.15 + 0.1 0.25 + 0.125 0.25 + 8.0	PRE 2-leaf 4-leaf Lay-by	22	15	75	100	87	13	64	677	198	960
Roundup + Prowl Buctril + Poast + Dacthal Buctril + Goal Goal + Dacthal	0.375 + 1.0 0.15 + 0.1 + 6.0 0.25 + 0.125 0.25 + 6.0	PRE 2-leaf 4-leaf Lay-by	15	15	85	100	78	13	62	756	209	1047
Roundup + Prowl Buctril + Poast Buctril + Goal Goal + Dacthal	0.375 + 1.0 0.15 + 0.1 0.25 + 0.125 0.25 + 12.0	PRE 2-leaf 4-leaf Lay-by	18	18	73	100	93	11	64	696	152	926
Roundup + Dacthal Buctril + Poast Buctril + Goal Goal + Dacthal	0.375 + 8.0 0.15 + 0.1 0.25 + 0.125 0.25 + 12.0	PRE 2-leaf 4-leaf Lay-by	23	14	73	100	74	18	75	620	125	838

Table 1. *(continued)* Onion injury, weed control, and yield response to soil-active herbicides.

Treatment	Rate	Timing*	Injury 5-24	Injury 6-27	Weed control† Redroot pigweed	Weed control† Common lambsquarters	Weed control† Hairy nightshade	Onion yield Small	Onion yield Medium	Onion yield Jumbo	Onion yield Colossal	Onion yield Total
Roundup + Dacthal	0.375 + 8.0	PRE	23	18	73	98	69	11	67	535	64	691
Buctril + Poast	0.15 + 0.1	2-leaf										
Buctril + Goal	0.25 + 0.125	4-leaf										
Goal + Dual Magnum	0.25 + 1.3	Lay-by										
Roundup + Dacthal	0.375 + 8.0	PRE	17	15	69	90	70	12	89	611	86	804
Buctril + Poast	0.15 + 0.1	2-leaf										
Buctril + Goal	0.25 + 0.125	4-leaf										
Goal + Outlook	0.25 + 0.64	Lay-by										
Roundup + Prowl	0.375 + 1.0	PRE	21	13	75	98	88	9	63	702	156	935
Buctril + Poast + Outlook	0.15 + 0.1 + 0.64	2-leaf										
Buctril + Goal	0.25 + 0.125	4-leaf										
Goal	0.25	Lay-by										
Roundup	0.375	PRE	27	15	83	100	86	8	37	773	238	1065
Prowl	0.63	flag leaf										
Buctril + Poast + Outlook + Prowl	0.15 + 0.3 + 0.33 + 0.63	2-leaf										
Buctril + Goal	0.25 + 0.125	4-leaf										
Goal + Outlook	0.25 + 0.33	Lay-by										
Roundup	0.375	PRE	7	15	59	92	64	21	87	562	76	751
Prowl	1.0	flag leaf										
Outlook	0.66	2-leaf										
Buctril + Goal	0.25 + 0.125	4-leaf										
Goal	0.25	Lay-by										
Roundup	0.375	PRE	27	15	69	100	98	9	42	734	214	1009
Prowl	1.0	flag leaf										
Buctril + Poast + Outlook	0.15 + 0.66 + 0.38	2-leaf										
Buctril + Goal	0.25 + 0.125	4-leaf										
Goal	0.25	Lay-by										
Roundup	0.375	PRE	21	15	85	100	73	10	57	712	191	977
Prowl	1.0	flag leaf										
Poast + Outlook + Goal	0.38 + 0.66 + 0.125	2-leaf										
Buctril + Goal	0.25 + 0.125	4-leaf										
Goal	0.25	Lay-by										
LSD (0.05)			6	4	12	6	13	12	NS	100	123	142

*Preemergence (PRE) treatment applied on April 16, flag leaf on April 23, two-leaf (2-leaf) on May 19, four-leaf (4-leaf) on May 31, and lay-by on June 15.
†Weed control ratings were taken June 27.

Table 2. Onion tolerance to Valor combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Onion injury			Onion yield‡				
Treatment*	Rate	Timing†	5-24	6-27	7-11	Small	Medium	Jumbo	Colossal	Total
	lb ai/acre	Leaf	%			cwt/acre				
Untreated	--	--	4	0	4	11	71	679	122	892
Valor + NIS Valor	0.063 0.063	2-leaf 6-leaf	49	10	0	11	45	738	236	1049
Valor + NIS Valor	0.094 0.094	2-leaf 6-leaf	46	9	5	11	59	734	140	959
Valor + NIS Valor	0.125 0.125	2-leaf 6-leaf	44	11	0	7	45	701	276	1041
Buctril + Valor Valor	0.15 + 0.063 0.063	2-leaf 6-leaf	32	5	3	6	47	786	199	1051
Buctril + Valor Valor	0.15 + 0.094 0.094	2-leaf 6-leaf	30	10	1	6	52	738	192	1001
Goal Goal	0.125 0.125	2-leaf 6-leaf	18	11	0	10	49	718	234	1029
Buctril + Goal Goal	0.15 + 0.125 0.125	2-leaf 6-leaf	28	8	0	7	57	717	200	987
LSD (0.05)			11	5	NS	NS	NS	NS	NS	NS

*All plots except the untreated received Roundup preemergence on April 17. Non-ionic surfactant (NIS) applied at 0.25 percent v/v.
†Treatments were applied on May 19 and June 15 to two-leaf (2-leaf) and six-leaf (6-leaf) onions, respectively.
‡Onions were harvested September 18.

Table 3. Weed control with postemergence nitrogen applications, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Weed control					
			Redroot pigweed		Common lambsquarters		Hairy nightshade	
Treatment	Rate	Timing*	6-27	9-11	6-27	9-11	6-27	9-11
	lb ai/acre	Leaf	%					
Untreated	--	--	0	0	0	0	0	0
32% N Buctril + Poast Goal Buctril + Goal Goal	20 gal/acre 0.15 + 0.1 0.125 0.25 + 0.125 0.25	1-leaf 2-leaf 3-leaf 4-leaf 6-leaf	94	55	86	86	62	8
Roundup + Prowl 32% N Buctril + Poast Goal Buctril + Goal Goal	0.375 + 1.0 20 gal/acre 0.15 + 0.1 0.125 0.25 + 0.125 0.25	PRE 1-leaf 2-leaf 3-leaf 4-leaf 6-leaf	98	69	100	100	97	68
Roundup + Dacthal 32% N Buctril + Poast Goal Buctril + Goal Goal	0.375 + 8.0 20 gal/acre 0.15 + 0.1 0.125 0.25 + 0.125 0.25	PRE 1-leaf 2-leaf 3-leaf 4-leaf 6-leaf	92	56	91	84	78	10
Buctril Buctril + Poast Goal Buctril + Goal Goal	0.05 0.15 + 0.1 0.125 0.25 + 0.125 0.25	1-leaf 2-leaf 3-leaf 4-leaf 6-leaf	98	60	86	80	86	36
Roundup + Prowl Buctril Buctril + Poast Goal Buctril + Goal Goal	0.375 + 1.0 0.05 0.15 + 0.1 0.125 0.25 + 0.125 0.25	PRE 1-leaf 2-leaf 3-leaf 4-leaf 6-leaf	99	87	100	100	99	93
32% N 32% N Buctril + Poast Goal Buctril + Goal Goal	20 gal/acre 20 gal/acre 0.15 + 0.1 0.125 0.25 + 0.125 0.25	flag 1-leaf 2-leaf 3-leaf 4-leaf 6-leaf	100	58	74	66	62	8
32% N Buctril + Poast Goal Buctril + Goal Goal	30 gal/acre 0.15 + 0.1 0.125 0.25 + 0.125 0.25	1-leaf 2-leaf 3-leaf 4-leaf 6-leaf	97	58	81	56	64	5
LSD (0.05)			4	27	12	25	8	20

*Treatments were applied preemergence (PRE) on April 16, flag leaf on April 26, one-leaf (1-leaf) on May 7, two-leaf (2-leaf) on May 19, three-leaf (3-leaf) on May 24, four-leaf (4-leaf) on May 31, and six-leaf (6-leaf) on June 15, 2001.

Table 4. Onion injury and yield with postemergence nitrogen applications, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Onion injury		Onion yield†				
Treatment	Rate	Timing*	5-24	6-27	Small	Medium	Jumbo	Colossal	Total
	lb ai/acre	Leaf	%		cwt/acre				
Untreated	--	--	0	0	42	5	0	0	47
32% N	20 gal/acre	1-leaf	13	15	18	141	488	27	682
Buctril + Poast	0.15 + 0.1	2-leaf							
Goal	0.125	3-leaf							
Buctril + Goal	0.25 + 0.125	4-leaf							
Goal	0.25	6-leaf							
Roundup + Prowl	0.375 + 1.0	PRE	20	17	10	61	741	249	1074
32% N	20 gal/acre	1-leaf							
Buctril + Poast	0.15 + 0.1	2-leaf							
Goal	0.125	3-leaf							
Buctril + Goal	0.25 + 0.125	4-leaf							
Goal	0.25	6-leaf							
Roundup + Dacthal	0.375 + 8.0	PRE	20	15	12	90	636	94	838
32% N	20 gal/acre	1-leaf							
Buctril + Poast	0.15 + 0.1	2-leaf							
Goal	0.125	3-leaf							
Bucril + Goal	0.25 + 0.125	4-leaf							
Goal	0.25	6-leaf							
Buctril	0.05	1-leaf	20	17	16	84	699	105	911
Buctril + Poast	0.15 + 0.1	2-leaf							
Goal	0.125	3-leaf							
Buctril + Goal	0.25 + 0.125	4-leaf							
Goal	0.25	6-leaf							
Roundup + Prowl	0.375 + 1.0	PRE	18	19	12	59	767	255	1107
Buctril	0.05	1-leaf							
Buctril + Poast	0.15 + 0.1	2-leaf							
Goal	0.125	3-leaf							
Buctril + Goal	0.25 + 0.125	4-leaf							
Goal	0.25	6-leaf							
32% N	20 gal/acre	flag	16	13	37	179	384	11	613
32% N	20 gal/acre	1-leaf							
Buctril + Poast	0.15 + 0.1	2-leaf							
Goal	0.125	3-leaf							
Buctril + Goal	0.25 + 0.125	4-leaf							
Goal	0.25	6-leaf							
32% N	30 gal/acre	1-leaf	18	15	29	163	419	22	635
Buctril + Poast	0.15 + 0.1	2-leaf							
Goal	0.125	3-leaf							
Buctril + Goal	0.25 + 0.125	4-leaf							
Goal	0.25	6-leaf							
LSD (0.05)			6	3	15	41	112	70	110

*Treatments were applied preemergence (PRE) on April 16, flag leaf on April 26, one-leaf (1-leaf) on May 7, two-leaf (2-leaf) on May 19, three-leaf (3-leaf) on May 24, four-leaf (4-leaf) on May 31, and six-leaf (6-leaf) on June 15, 2001.
†Onions were harvested September 18.

Table 5. Spray volume effects on weed control and onion injury, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

						Weed control					
				Onion injury		Redroot pigweed		Common lambsquarters		Hairy nightshade	
Treatment*	Rate	Spray Volume	Timing†	5-24	6-27	6-27	7-11	6-27	7-11	6-27	7-11
	lb ai/acre	gal/acre	Leaf	%							
Untreated	--	--	--	0	0	0	0	0	0	0	0
Goal	0.125	35	2-lf & 4-lf	17	0	54	49	51	41	48	27
Goal	0.25	35	2-lf & 4-lf	20	0	83	85	83	82	34	0
Goal	0.125	100	2-lf & 4-lf	21	0	62	60	63	53	56	15
Goal	0.25	100	2-lf & 4-lf	26	4	83	81	81	79	61	22
Buctril	0.25	35	2-lf & 4-lf	12	0	34	15	100	93	88	84
Buctril	0.25	100	2-lf & 4-lf	18	2	39	28	74	70	97	93
Buctril + Goal	0.25 + 0.25	100	2-lf & 4-lf	23	9	97	91	96	96	88	91
LSD (0.05)				10	3	16	20	14	21	19	32

*All plots received Roundup (0.375 lb ai/acre) preemergence on April 14 and Select (0.125 lb ai/acre) plus Crop Oil Concentrate (1 percent v/v) on May 18.
†Applications were made to two-leaf (2-lf) onions May 19 and to four-leaf (4-lf) onions on May 31.

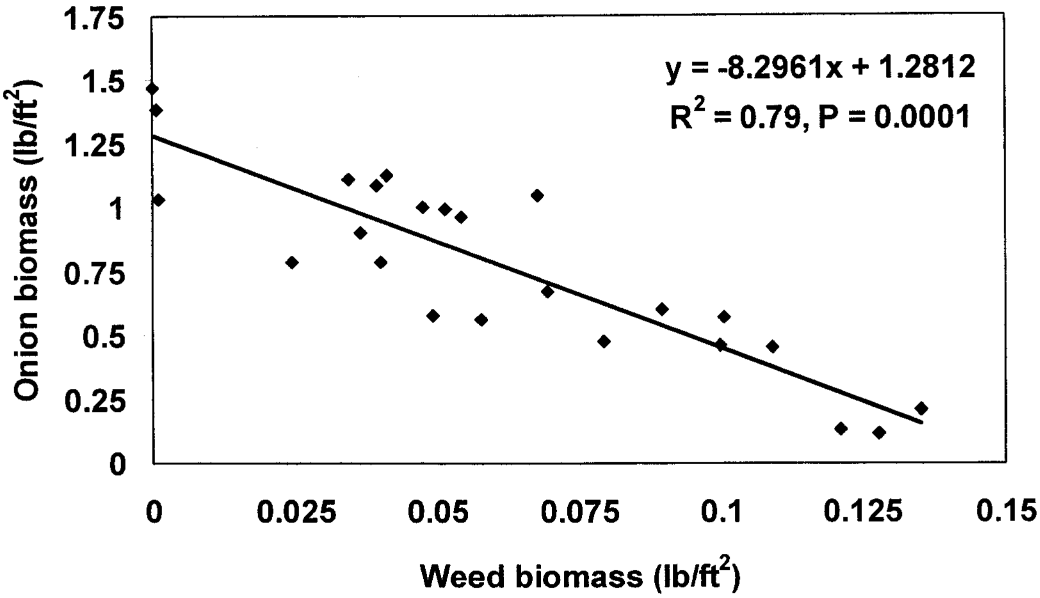

Figure 1. Relationship of total dry weed biomass versus total dry onion biomass in spray volume study, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

HERBICIDE APPLICATION METHODS FOR CONTROL OF YELLOW NUTSEDGE IN ONIONS

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Introduction

Yellow nutsedge is extremely competitive with onions, and herbicide options for controlling yellow nutsedge in onions are limited. Dual Magnum is registered for controlling yellow nutsedge in onions grown in the Treasure Valley. Outlook has also been evaluated for this use. Dual Magnum has been applied in various ways and questions about the most effective application method led to this trial. In addition, yellow nutsedge tuber production and distribution in the soil were determined.

Methods

Application Methods for Yellow Nutsedge Control

This trial was conducted to determine the effect of application methods of Dual Magnum and Outlook on yellow nutsedge control and onion injury. The trial was established in a cooperators' field heavily infested with yellow nutsedge. Onions were planted on a 3.7-inch spacing in double rows on 22-inch beds on April 13. Plots were four rows wide and 30 ft long and arranged in a randomized complete block design with four replications.

Dual Magnum and Outlook were applied as a broadcast spray, a spray banded in the furrow, and sidedressed. In some treatments, initial applications of Dual Magnum or Outlook were followed with a second application of the same product or an application of Basagran plus crop oil concentrate (COC). Basagran plus COC was also applied twice for comparison. Initial herbicide applications were made on June 8, and second applications were made on July 6. At the first application, onions had three leaves and the yellow nutsedge was 6 inches tall. At the second application, onions had five leaves and the nutsedge was 10 inches tall. Nutsedge control was evaluated throughout the season. Because of poor onion establishment and heavy competition from the yellow nutsedge, onion injury was not evaluated and onion yields were not recorded from this trial.

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

Yellow Nutsedge Tuber Yield and Soil Distribution in Untreated Onions

On August 14, soil core samples were randomly taken from a 400-ft^2 area in a field with an extremely high yellow nutsedge population to determine the number, soil distribution, and production of tubers. The soil core probe had a 4.25-inch diameter and was 10 inches long. Soil cores were replicated four times. Soil from the core samples were separated into 2-inch increments. Soil was washed from the samples, and nutsedge tubers were collected and dried. Non-viable tubers (those that could be crushed easily between the fingers) were removed and the remaining tubers were counted and weighed.

Results and Discussion

Application Methods for Yellow Nutsedge Control

Poor onion stand and extreme yellow nutsedge competition prevented evaluation of onions for herbicide injury and onion harvest. On July 6, sidedress applications of Outlook provided greater yellow nutsedge control than broadcast or in-furrow banded applications (Table 1). Yellow nutsedge control with Dual Magnum was equal between application methods on this date. On July 13, Outlook or Dual Magnum sidedressed had greater yellow nutsedge suppression than when broadcast. On this date, treatments that had received Basagran had the highest yellow nutsedge control. On August 3, all plots with two applications, except for the two broadcast applications of Outlook, had significantly greater yellow nutsedge control than any of the single applications. On this date, treatments with single applications of Dual Magnum had greater control than Outlook treatments regardless of the application method. Adding COC to Dual Magnum and Outlook did not improve yellow nutsedge control.

Yellow Nutsedge Tuber Yield and Soil Distribution in Untreated Onions

Soil cores taken from various soil depths in 2001 showed similar trends in yellow nutsedge tuber numbers and biomass to those taken in 1999 and 2000 (Table 2). The majority of tubers were found in the top 2 inches of soil with tuber numbers decreasing with increasing soil depth (Fig. 1). The greatest weight of tubers was found in the top 4 inches of soil in 2001, whereas in 1999 the 4- to 6-inch soil layer had greater tuber biomass than the 0- to 2-inch layer. Total yellow nutsedge tuber numbers and biomass in 2000 and 2001 were approximately half of that in 1999.

Table 1. Yellow nutsedge control in response to herbicide application methods in onions, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	Timing*	Application method	Yellow nutsedge control 7-6	7-13	8-3
	lb ai/acre	leaf		%		
Dual Magnum	1.25	3-leaf	Sidedress	42	50	38
Outlook	0.64	3-leaf	Sidedress	44	35	15
Dual Magnum	1.25	3-leaf	Broadcast	38	25	30
Outlook	0.64	3-leaf	Broadcast	18	8	0
Dual Magnum	1.25	3-leaf	Band in furrow	38	38	22
Outlook	0.64	3-leaf	Band in furrow	26	22	10
Dual Magnum Dual Magnum	1.25 1.25	3-leaf 5-leaf	Sidedress Broadcast	73	51	71
Outlook Outlook	0.64 0.64	3-leaf 5-leaf	Sidedress Broadcast	58	58	62
Dual Magnum Dual Magnum	1.25 1.25	3-leaf 5-leaf	Broadcast Broadcast	36	43	63
Outlook Outlook	0.64 0.64	3-leaf 5-leaf	Broadcast Broadcast	28	25	37
Basagran + COC Basagran + COC	1.0 + 1% v/v 1.0 + 1% v/v	3-leaf 5-leaf	Broadcast Broadcast	23	88	65
Dual Magnum Basagran + COC	0.64 1.0 + 1% v/v	3-leaf 5-leaf	Broadcast Broadcast	34	88	78
Outlook Basagran + COC	0.64 1.0 + 1% v/v	3-leaf 5-leaf	Broadcast Broadcast	25	88	63
Dual Magnum + COC	1.25 + 1% v/v	3-leaf	Broadcast	35	35	25
Outlook + COC	0.64 + 1% v/v	3-leaf	Broadcast	27	24	10
Untreated				0	0	0
LSD (0.05)				15	14	18

*Treatments were applied to 3-leaf onions on June 8 and to 5-leaf onions on July 6.

Table 2. Yellow nutsedge tuber number and weight at various soil depths in 1999, 2000, and 2001, Malheur Experiment Station, Oregon State University, Ontario, OR.

	Tuber number			Tuber weight		
Soil depth *	1999	2000	2001	1999	2000	2001
inches	---------------No./m²------------			-----------------g/m²---------------		
0-2	7,325	2,842	5,494	242	177	308
2-4	5,758	1,941	3,526	360	161	325
4-6	3,644	1,312	984	430	151	127
6-8	1,640	820	82	175	85	7
8-10	1,385	109	246	112	30	12
LSD (0.05)	1,436	NS	1,904	168	NS	171
Total	19,752	7,024	10,332	1,319	604	779

*Samples were taken with a 4.25-inch diameter soil probe 10 inches long.

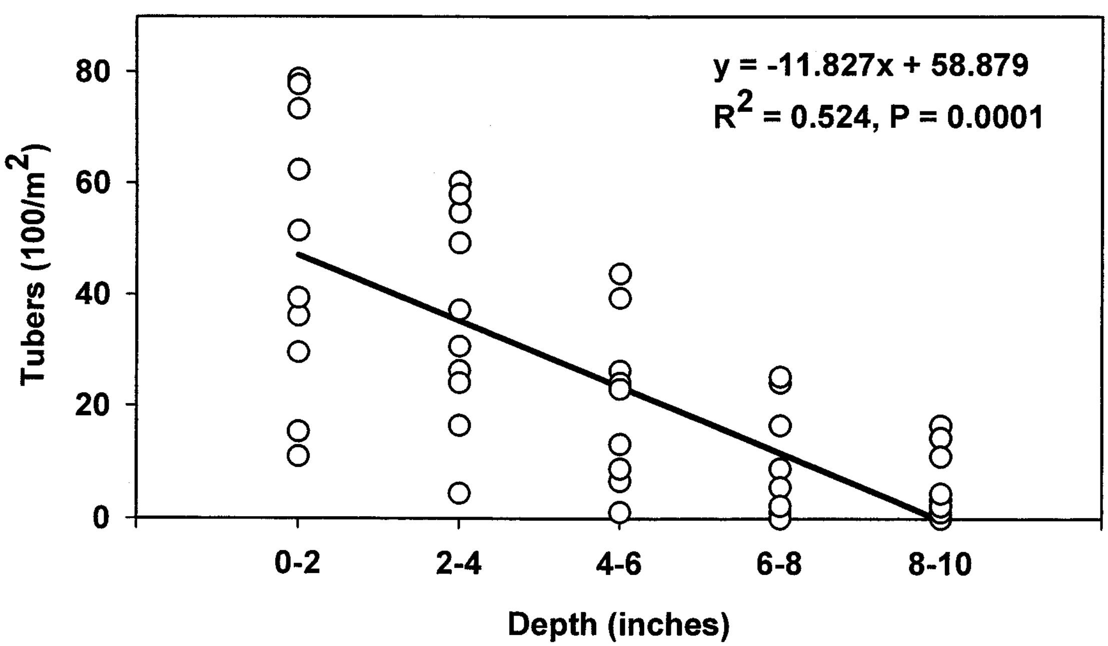

Figure 1. Relationship of yellow nutsedge tuber density and soil depth from combined data from samples taken in 1999, 2000, and 2001.

VOLUNTEER POTATO CONTROL IN ONIONS

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Introduction

Many producers raise onions in rotation with potatoes. During potato harvest not all of the potato tubers are removed from the field. Tubers remaining in the field can survive the winter and become a weed in the following crop. Volunteer potatoes are extremely competitive with onions and are not effectively controlled with herbicides currently registered for use on onions. Volunteer potatoes can serve as hosts for late blight, verticillium wilt, viruses, and nematodes. Starane, a new herbicide registered for volunteer potato control in corn, may control volunteer potatoes effectively in onions. Starane was evaluated for volunteer potato control and for onion tolerance.

Methods

A trial was established at the Malheur Experiment Station to evaluate Starane, Buctril, and Goal for volunteer potato control in onions. The soil was an Owyhee Silt Loam with pH 7.2 and 1.6 percent organic matter. Potatoes were planted prior to onion seeding on April 27. Potatoes were planted in one-half of each plot so that herbicide effects on onions could be evaluated with and without potato competition. Single drop 'Norkotah' potato tubers were planted 6 inches deep directly into the two center rows of each plot with a spacing of one seed every 3 ft. Potato tubers weighed approximately 2 oz each. Onions (cv. 'Vision', Petoseed) were planted at a 3.7-inch spacing in double rows on 22-inch beds on April 29. Plots were four rows wide by 40 ft long. Lorsban was applied on a 6-inch band over each onion row at 3.7 oz per 1,000 ft of row. Onions were sidedressed with 150 lb N/acre as urea on May 23.

Annual weeds were controlled by applying Roundup (0.75 lb ai/acre) plus Prowl (1.5 lb ai/acre) prior to onion emergence on April 17 and Select (0.125 lb ai/acre) on May 18. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Herbicide treatments for volunteer potato control were applied on May 19, May 31, and June 14. At the first application, onions had two true leaves and potato plants were 5 inches tall. At the second application, onions had four true leaves and potatoes were 9 inches tall. The last application was to six-leaf onions and 16-inch-tall potatoes. All plots were maintained free of weeds other than volunteer potatoes by hand weeding regardless of herbicide effectiveness to allow the evaluation of the negative effects of volunteer potatoes on the onions.

Insecticides and fungicides were applied for thrips and downy mildew control as needed. On September 14, prior to onion harvest, potato tubers were dug, counted, and weighed for all potato plants in each plot to determine the effect of the herbicide treatments on tuber production. Tubers were placed in cold storage after harvest and maintained at approximately 90 percent relative humidity. The temperature was gradually reduced to 45°F. Tubers were taken directly from storage and evaluated for sprouting on February 28, 2002. Sprouting was evaluated by counting the number of tubers without sprouts, the number of tubers with sprouts < 0.25 inch long, the number of tubers with sprouts > 0.25 inch long, and the total number of sprouts. Decomposing tubers were not evaluated. Tuber and sprout numbers were used to calculate the percent of tubers sprouting and the average number of sprouts per tuber.

Onion yield and grade were determined by harvesting the two center rows from each plot on September 13 and grading the onions by size on September 20.

Results and Discussion

Onion injury was greatest immediately after Starane applications and lessened over time (Table 1). Injury from herbicide applications to two-leaf onions ranged from 24 to 38 percent on May 24. Starane applied to two-leaf onions at 0.25 lb ai/acre produced greater injury than Starane applied at 0.125 lb ai/acre. On June 27, 13 days after the six-leaf application, onion injury was greatest in plots treated with Buctril plus Goal (two-leaf) followed by Starane (four-leaf) followed by Buctril plus Goal (six-leaf). On July 11, all treatments except Starane (0.25 lb ai/acre) applied at the two-leaf and four-leaf timings injured onions greater than the untreated check.

Volunteer potato control on June 27 and July 11 was greatest with treatments of or including Starane (0.5 lb ai/acre) applied to four-leaf onions or Starane (0.125 lb ai/acre) applied sequentially to two-, four-, and six-leaf onions (Table 1). Volunteer potato was completely controlled on July 11 with Starane applied at 0.5 lb ai/acre.

Volunteer potato tuber yields were variable and were not different among treatments with regard to number of tubers produced per plant, total weight of tubers per plant, or the average weight of individual tubers (Table 1). Evaluations of tuber sprouting showed that all treatments reduced the percent of tubers producing sprouts > 0.25 inch long and the average number of sprouts per tuber (Table 2). All treatments including Starane significantly reduced the percent of tubers with sprouts > 0.25 inch, percent of tubers sprouting, and the average sprouts per tuber compared to the sequential treatment of Buctril plus Goal.

Competition from volunteer potatoes was severely reduced due to disease symptoms visible on the majority of potato plants, including those in the untreated check. Despite reduced competition from volunteer potatoes, onion yields were generally greater in plots without volunteer potatoes (Table 3). Marketable onion yields were similar in plots both with and without potatoes for treatments including Starane (0.125 lb ai/acre) applied to two-, four-, and six-leaf onions, Starane (0.25 lb ai/acre) applied to four- and six-leaf onions, and Buctril plus Goal followed by Starane (0.5 lb ai/acre) followed by Buctril plus Goal. Early potato competition evidently reduced onion yields in plots treated with Starane (0.5 lb ai/acre) at the four-leaf onion growth stage.

Table 1. Onion injury and volunteer potato control with postemergence herbicide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	Timing*	Onion injury 5-24	Onion injury 6-27	Onion injury 7-11	Volunteer potato control 5-24	Volunteer potato control 6-27	Volunteer potato control 7-11	Tuber production per plant Weight	Tuber production per plant Number	Tuber production per plant Ave. tuber weight
	lb ai/acre	Leaf stage	%			%			grams		grams
Starane Starane Starane	0.125 0.125 0.125	2-leaf 4-leaf 6-leaf	24	26	6.3	40	96	95	31	0.6	44
Starane Starane	0.25 0.25	2-leaf 4-leaf	38	16	1.3	41	91	87	53	1.1	50
Starane	0.5	4-leaf	0	20	8.8	0	100	100	5	0.3	18
Buctril + Goal Starane Buctril + Goal	0.15 + 0.12 0.5 0.2 + 0.15	2-leaf 4-leaf 6-leaf	30	39	10	43	98	95	16	0.4	52
Buctril + Goal Buctril + Goal Buctril + Goal	0.15 + 0.12 0.2 + 0.15 0.2 + 0.15	2-leaf 4-leaf 6-leaf	34	29	6.3	36	24	15	106	1.2	92
Untreated	--	--	0	0	0	0	0	0	256	1.8	113
LSD (0.05)			5	8	6.2	3	5	6	NS	NS	NS

*Treatments were applied on May 19 (2-leaf), May 31 (4-leaf), and June 14 (6-leaf).

Table 2. Volunteer potato tuber sprouting after storage in response to postemergence herbicide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	Timing*	Tuber† With sprouts <0.25 in long	Tuber† With sprouts >0.25 in long	Tuber† Total sprouting	Average sprouts per tuber
	lb ai/acre	Leaf stage	%	%	%	No./tuber
Starane Starane Starane	0.125 0.125 0.125	2-leaf 4-leaf 6-leaf	46	7	53	1
Starane Starane	0.25 0.25	2-leaf 4-leaf	37	3	40	2
Starane	0.5	4-leaf	0	0	0	0
Buctril + Goal Starane Buctril + Goal	0.15 + 0.12 0.5 0.2 + 0.15	2-leaf 4-leaf 6-leaf	25	0	25	1
Buctril + Goal Buctril + Goal Buctril + Goal	0.15 + 0.12 0.2 + 0.15 0.2 + 0.15	2-leaf 4-leaf 6-leaf	40	41	81	5
Untreated	--	--	8	87	95	8
LSD (0.05)			NS	10	41	2

*Treatments were applied on May 19 (2-leaf), May 31 (4-leaf), and June 14 (6-leaf).
†Tubers were evaluated for sprouting on February 28, 2002.

Table 3. Marketable onion yield in response to Starane applications, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	Timing*	Marketable onion yield† With potatoes	Marketable onion yield† Without potatoes
	lb ai/acre	Leaf stage	cwt/acre	cwt/acre
Starane Starane Starane	0.125 0.125 0.125	2-leaf 4-leaf 6-leaf	824 cde	845 bcd
Starane Starane	0.25 0.25	2-leaf 4-leaf	832 bcde	901 ab
Starane	0.5	4-leaf	798 de	927 a
Buctril + Goal Starane Buctril + Goal	0.15 + 0.12 0.5 0.2 + 0.15	2-leaf 4-leaf 6-leaf	819 cde	817 cde
Buctril + Goal Buctril + Goal Buctril + Goal	0.15 + 0.12 0.2 + 0.15 0.2 + 0.15	2-leaf 4-leaf 6-leaf	765 e	867 abcd
Untreated	--	--	587 f	871 abc
LSD (0.05)			69	

*Treatments were applied on May 19 (2-leaf), May 31 (4-leaf), and June 14 (6-leaf).
†Onion yields followed by the same letter are not statistically different from each other.

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

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Introduction

Onion thrips are the major insect pest of onions in the Idaho-eastern Oregon production area. Many growers are making four to six insecticide applications during the growing season in order to keep the pest suppressed enough to maintain economic yields. Thrips control with Warrior, the most commonly used insecticide treatment, has gone from over 90 percent control in 1995 to less than 60 percent in 2000. New insecticides or new methods of using currently registered products are needed in order to keep onion thrips under control.

Materials and Methods

This trial was established on the edge of a commercial onion field near Nyssa, Oregon. The onion variety was 'Vaquero'. Pre-counts were made on June 14. The initial treatments were applied on June 15, with sequential treatments on June 20 and June 27 (Table 1). Evaluations were made on June 20 and July 6 by randomly selecting 15 plants within each treatment and counting the total number of thrips on each plant.

Individual plots were 6.67 ft wide (four double rows) by 50 ft in length. Each treatment was replicated four times in a randomized complete block design. Treatments included Warrior, Capture, Mustang, Furadan, Meta Systox R, Ecozin, Aza Direct, and Messenger. Capture, Warrior, and Mustang are all members of the synthetic pyrethroid class of insecticides and have similar modes of activity. Furadan is a systemic carbamate and Meta Systox R is an organophosphate insecticide. Ecozin and Aza Direct are naturally occurring extracts of the neem tree that work as an insect growth regulator (IGR) to disrupt the normal growth of insects.

Three sequential applications were made to evaluate the effectiveness of the IGR materials. Messenger is a harpin protein material thought to enhance the plant's ability to adapt to stress. Furadan, Capture, and Meta Systox R are not currently registered for use on onions.

Results and Discussion

Furadan gave consistently good control and was the best treatment at each evaluation date (Table 2). All of the treatments were significantly different from the check but not from each other in the June 20 evaluation.

At the June 26 evaluation date Furadan was significantly better than Ecozin, Mustang, and the Warrior + Ecozin 10-oz treatments. All of the treatments except Ecozin were significantly better than the untreated check.

Furadan was significantly better than the Warrior + Ecozin 10 oz and Ecozin treatments at the July 6 evaluation date. All of the treatments except Ecozin were better than the untreated check.

The addition of the harpin protein Messenger to Warrior did not improve thrips control in any of the evaluations. The addition of the neem tree extracts, Ecozin or Aza Direct, did not improve thrips control over Warrior alone. The synthetic pyrethroid Capture provided better thrips control on June 26 compared to Warrior but less control than Warrior on the other two evaluation dates. These differences were not significant. Mustang treatments did not significantly differ from Warrior.

Conclusions

Furadan gave excellent thrips control at all evaluation dates.

The addition of Ecozin, Aza Direct, MSR, or Messenger to Warrior did not improve thrips control.

Table 1. Application data for insecticide treatments to control onion thrips, Nyssa, OR, 2001.

		First application	Second application	Third application
Date		6/15/2001	6/20/2001	6/27/2001
Time		12:00 – 1:30 p.m.	4:30 – 5:30 p.m.	1:30 – 3:00 p.m.
Temperature		79°F	86°F	85°F
Wind	high	3.0 mph	---	2.7 mph
	Average	1.1 mph	4.0 mph	1.9 mph
Relative Humidity		28%	---	47%

Table 2. Average number of thrips on each plant after insecticide treatment, Nyssa, OR, 2001.

Treatment*	Rate/acre	Evaluation date		
		6/20/01	6/26/01	7/6/01
		--------average number thrips per plant-----		
Furadan†	32.0 oz	1.0	0.5	4.4
Warrior	3.84 oz	2.0	3.4	6.0
Warrior Messenger	3.84 oz + 4.6 oz	2.2	2.7	6.5
Warrior† Meta Systox R	3.84 oz + 24.0 oz	2.3	2.2	9.2
Warrior Messenger	3.84 oz + 2.3 oz	4.2	3.4	9.9
Warrior† Aza Direct	3.84 oz + 42.0 oz	2.1	3.8	11.2
Warrior† Ecozin	3.84 oz + 4.0 oz	3.1	3.6	11.3
Mustang	4.26 oz	1.9	5.0	11.9
Capture	6.4 oz	3.0	2.3	11.9
Warrior† Ecozin	3.84 oz + 10.0 oz	1.8	3.6	12.1
Ecozin†	10.0 oz	3.7	13.0	17.0
Untreated Check	---	11.1	10.9	23.5
	LSD (0.05)	3.3	3.4	7.6

*Each treatment receiving 16.0 oz/ac Breakthrough silicone adjuvant.

†Received 16.0 oz/ac Indicate as a buffering agent.

Table 3. Percent of thrips control as compared to the untreated check from insecticide applications, Nyssa, OR, 2001.

Treatment*	Rate/acre	Evaluation date 6/20/01	6/26/01	7/6/01
		---------------Percent of Control------------		
Furadan†	32.0 oz	91.0	95.4	81.3
Warrior	3.84 oz	82.0	68.8	74.5
Warrior Messenger	3.84 oz + 4.6 oz	80.2	75.2	72.3
Warrior† Meta Systox R	3.84 oz + 24.0 oz	79.3	79.8	60.9
Warrior Messenger	3.84 oz + 2.3 oz	62.2	68.8	57.9
Warrior† Aza Direct	3.84 oz + 42.0 oz	81.1	65.1	52.3
Warrior† Ecozin	3.84 oz + 4.0 oz	72.1	67.0	51.9
Mustang	4.26 oz	82.9	54.1	49.4
Capture	6.4 oz	73.0	78.9	49.4
Warrior† Ecozin	3.84 oz + 10.0 oz	83.8	67.0	48.5
Ecozin†	10.0 oz	66.7	0	27.7
Untreated Check	---	0	0	0
	LSD (.05)	29.7	31.2	32.3

*Each treatment receiving 16.0 oz/ac Breakthrough silicone adjustment.
†Received 16.0 oz/ac Indicate as a buffering agent.

ALTERNATIVE METHODS FOR CONTROLLING ONION THRIPS (*THRIPS TABACI*) IN SPANISH ONIONS

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Oregon State University
Ontario, OR, 2001

Introduction

Onions are a major economic crop in the Treasure Valley production region of eastern Oregon and western Idaho. Annually about 20,000 acres of onions are grown in the valley. Typically the onions are Spanish hybrids and are grown for their large size, high yield, and mild flavor. The value of the Treasure Valley onion industry for the 2000 production year was 94 million dollars. Over the past 10 years the value of the industry has ranged from a high of 140 million dollars to a low of 75 million depending upon market fluctuations.

The principle onion pest in this region is the onion thrips (*Thrips tabaci*, Lindeman) that causes yield reductions by feeding on the epidermal cells of the plant, thus reducing the photosynthetic ability of the plant. Onion thrips can reduce total yields from 4 to 27 percent, depending on variety, but may reduce yields of colossal sized bulbs from 28 percent 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 gone 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.

Mechanical straw mulching was introduced in 1985 as a means of improving irrigation water infiltration and reducing sediment loss. Some growers using this technique reported having decreased onion thrips pressure; a possible explanation for this may be enhanced habitat for predators.

New biological insecticides have been developed, including neem tree extracts (azadirachtin) and bacterial fermentation (spinosad). Both of these materials have previously been evaluated for thrips control and have performed poorly compared to the conventional insecticides. It was decided to test these products, along with Messenger, a harpin protein thought to enhance the plant's ability to withstand stress, in combination with straw mulch to provide predator habitat as an alternative program to the conventional insecticide program currently used by growers.

Materials and Methods

A 1.8-acre field was planted to onions (cv. 'Vaquero', Sunseeds, Brooks, OR) on March 23, 2001. 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 15 G 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. The field was divided into plots 40.3 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 practice included Warrior (lambda-cyhalothrin) and Lannate (methomyl). The 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), Ecozin or Aza Direct (azadirachtin neem extract), and Messenger (harpin protein).

Insecticide treatments were applied weekly or biweekly during the first half of the growing season (Table 1). All insecticides were applied with water at 29.7 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 23 at a rate of 952 lb/acre.

Thrips populations were sampled by two methods. The first was by visually counting the number of thrips on five plants. The second method was by cutting five plants at ground level and inserting the plants into a modified Berlese funnel designed to hold the plants. Turpentine was used 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 though the growing season.

The predator populations were monitored using pitfall traps that contained ethylene glycol. They were evaluated three times per week. The modified Berlese funnel was also used to monitor predators foraging on the plants.

Results and Discussion

The onions in the conventional treatment and the alternative control treatments looked similar throughout the growing season, with minimal thrips damage to the foliage. In contrast, the onions in the untreated check treatment had severe foliage damage due to thrips feeding. The thrips population as determined by the modified Berlese funnel is shown in Figure 1.

The visual plant counts (Fig. 2) did not correlate well with the funnel counts. Each is an average of five plants.

Some of the sample dates had statistical differences in thrips populations as shown in Tables 2 and 3.

Predator composition varied throughout the season but consisted mostly of spiders, big-eyed bugs, damsel bugs, and minute pirate bugs, with smaller populations of lacewings, ladybugs, assassin bugs, and rove beetles (Fig. 3). Spiders were initially more prevalent, followed by big-eyed bugs. Late in the season, minute pirate bugs were the dominant predator.

The highest populations of predators were in the alternative control plots, particularly early in the growing season (Table 4). Predator populations increased in the unsprayed and conventionally sprayed plots in August, but decreased slightly in the alternative control plots, although the population was still well above the conventionally sprayed plots.

The onions were harvested on September 13 and graded on September 14 and 17 (Table 5). There was a significant increase in super colossal size bulbs in the alternative treatment compared to the untreated check. There was also a significant difference between the treatments and the untreated check in total yield. There was a trend towards more super colossals and greater total yield in the alternative control treatment compared to the standard control, but this was not statistically significant.

Conclusion

The alternative methods in this trial worked as well or better than standard grower practices. The test was not designed to determine the individual effects of straw, spinosad, azadirachtin, or harpin protein on yield and quality, but only to answer the question of whether these materials in combination might give thrips control, yield, and quality similar to the conventional spray program. While thrips control with the alternative program was not as good as the conventional program, yield and quality were excellent. The next challenges will be to determine if these results can be repeated, and to evaluate what each alternative product is contributing towards thrips control, yield, and quality.

Table 1. Application data for the alternative methods for controlling onion thrips trial. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Standard treatments				Alternative treatments			
Date applied	Product	Formulation	Rate/acre	Date applied	Product	Formulation	Rate/acre
6/6	Warrior	1.0 lb/gal E.C.	4.0 oz	5/21	Messenger	Harpin protein 3%	2.8 oz
	MSR	2.0 lb/gal E.C.	1.0 qt	5/24	Messenger	Harpin protein 3%	3.5 oz
6/14	Warrior	1.0 lb/gal E.C.	4.0 oz	6/6	Success	2.0 lb/gal a.i.	10 oz
	Lorsban	4.0 lb/gal E	1.0 qt	6/13	Success	2.0 lb/gal a.i.	10 oz
6/30	Warrior	1.0 lb/gal E.C.	4.0 oz		Messenger	Harpin protein 3%	4.5 oz
7/9	Warrior	1.0 lb/gal E.C.	4.0 oz	6/21	Ecozin	3% E.C.	10 oz
	Lannate LV	2.4 lb/gal WSP	3.0 pt		Success	2.0 lb/gal a.i.	10 oz
7/16	Warrior	1.0 lb/gal E.C.	4.0 oz	6/29	Ecozin	3% E.C.	10 oz
	Lannate LV	2.4 lb/gal WSP	3.0 pt		Success	2.0 lb/gal a.i.	10 oz
					Messenger	Harpin protein 3%	4.5 oz
				7/9	Ecozin	3% E.C.	10 oz
					Success	2.0 lb/gal a.i.	10 oz
					Messenger	Harpin protein 3%	4.5 oz
				7/16	Ecozin	3% E.C.	10 oz
					Success	2.0 lb/gal a.i.	10 oz
				7/31	Success	2.0 lb/gal a.i.	10 oz
					Aza Direct	1.2% E.C.	10 oz

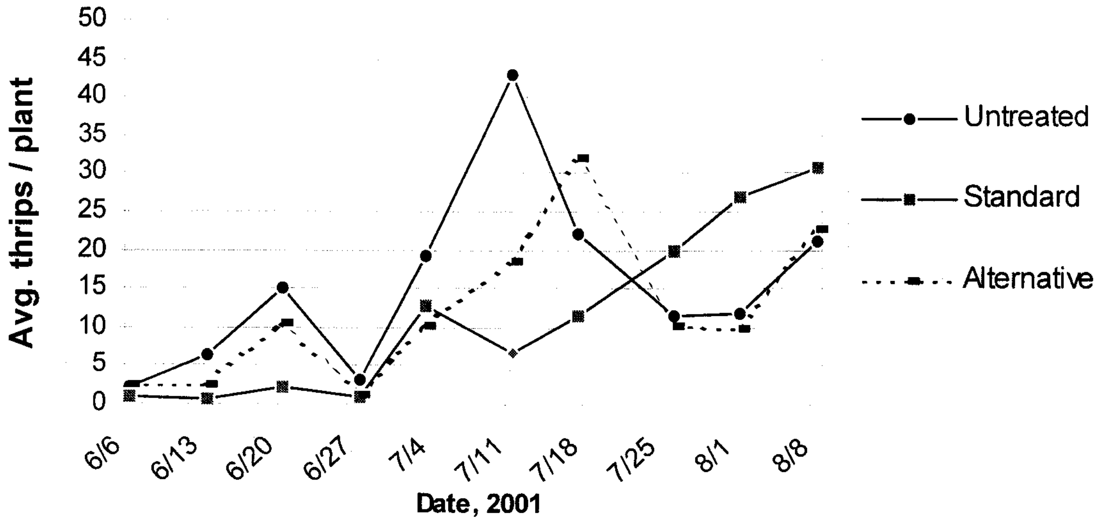


Figure 1. Thrips populations during the growing season from modified Berlese funnel traps. Malheur Experiment Station, Ontario, OR, 2001.

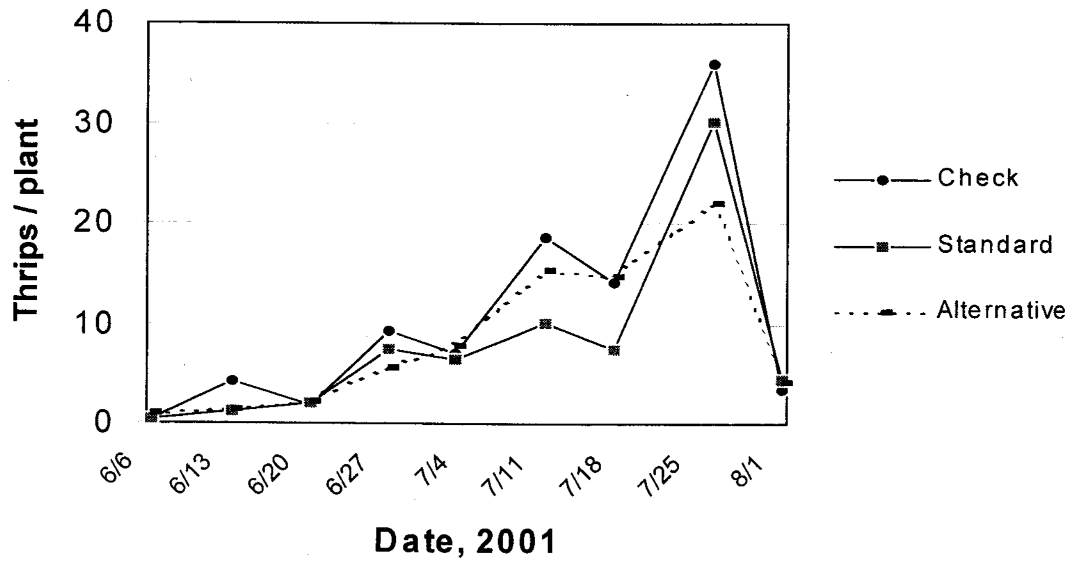


Figure 2. Thrips populations during the growing season from visual plant counts. Malheur Experiment Station, Ontario, OR, 2001.

Table 2. Weekly thrips population as counted visually on five plants. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Date:	6/06	6/13	6/20	6/27	7/03	7/11	7/17	7/26	8/01
Check	0.5	4.3	1.9	9.3	7	18.5	14.1	36	3.4
Standard	0.4	1.3	2	7.4	6.5	10.2	7.4	30.1	4.5
Alternative	1	1.5	2.2	5.7	7.8	15.3	14.8	21.6	4.3
LSD (0.05)	NS	NS	NS	NS	NS	6.2	5.9	NS	NS

Table 3. Weekly thrips population from Berlese funnel counts on five plants. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Date:	6/06	6/13	6/20	6/27	7/03	7/11	7/17	7/26	8/01	8/08
Check	2.1	6.4	15.2	3.3	19.1	43	22.1	11.5	11.7	21.3
Standard	1.0	0.6	2.4	0.9	12.7	6.7	11.5	19.9	27	30.7
Alternative	2.7	2.6	10.5	1.3	10.2	18.6	32	10.4	10	22.7
LSD (0.05)	NS	4.1	NS	1.5	NS	18.8	NS	NS	12.0	NS

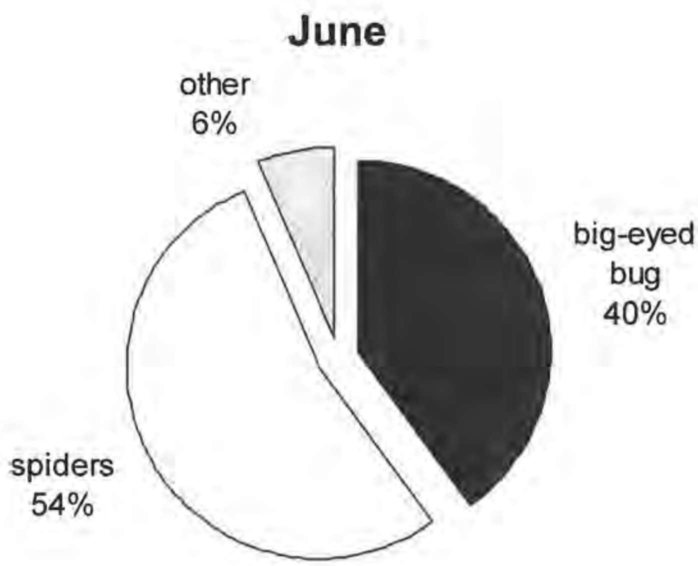
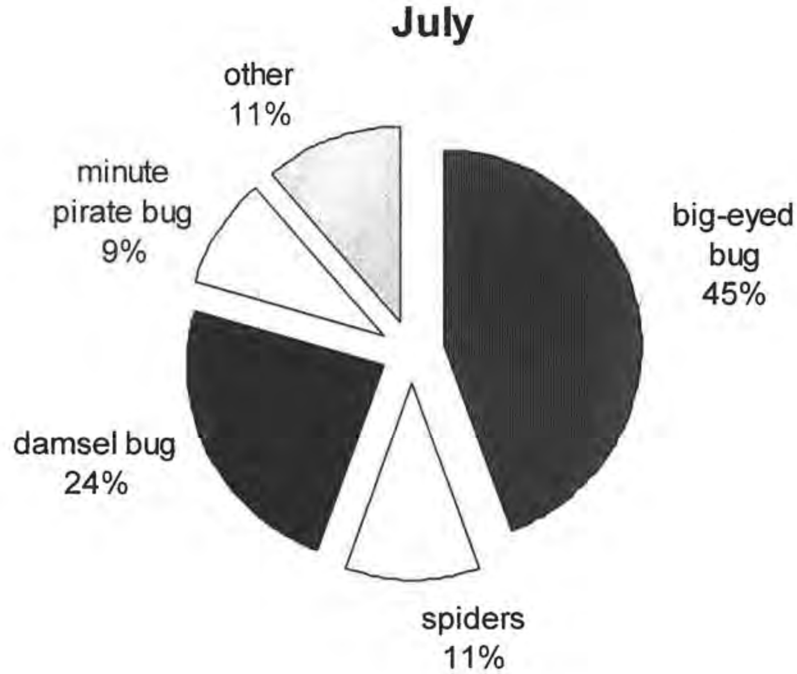


Figure 3. Predator composition by month. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.



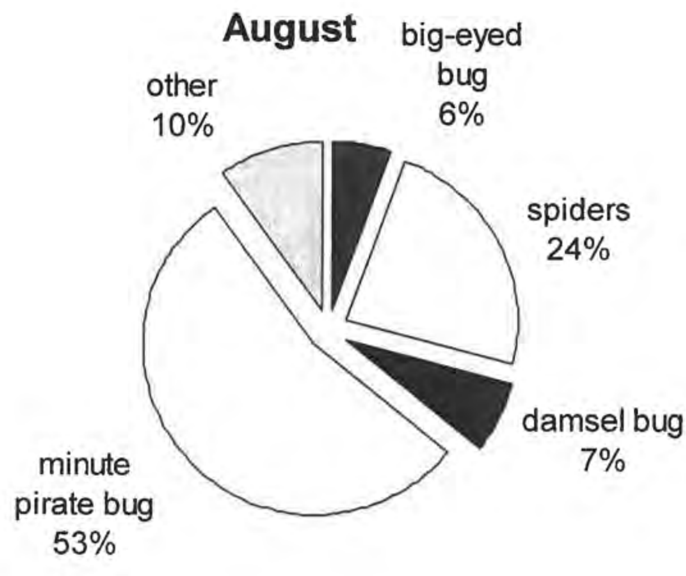


Figure 3. (*continued*) Predator makeup by month. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Table 4. Comparison of predator population by month and by treatment as measured by pitfall traps and Berlese funnel. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

	June	July	August	Total
Check	26	25	43	94
Standard	5	6	13	24
Alternative	64	57	33	154
LSD (0.05)	NS	NS	6.2	44.5

Table 5. Onion grade and yield as influenced by commercial and alternative insecticide controls. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

	Yield						
Treatment	Super colossal >4¼ in	Colossal 4-4¼ in	Jumbo 3-4 in	Total Super col. colossal jumbos	Medium 2¼-3 in	Total marketable yield	No. 2
	cwt/acre						
Untreated check	32.1	193.1	612.7	837.9	49.4	887.3	23.5
Standard	46.9	254.5	628.8	930.2	36.4	966.6	27.2
Alternative control	63.7	305.1	609.6	978.4	30.2	1,008.6	24.5
LSD (0.05)	23.8	NS	NS	94.8	NS	64.0	NS

EVALUATION OF NECK LENGTH AND INSECTICIDE TREATMENTS FOR THRIPS CONTROL IN STORED ONIONS

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Introduction

Controlling thrips in onions has become increasingly difficult over the past decade. Consequently, the maturing crop has a higher population of thrips than in prior years. Harvesting procedures have also changed for processed onions; some onions are topped while the necks are immature, cured for 1-2 days, and then brought into storage for heat curing. This process has increased the problem of thrips damage in storage. Thrips continue to feed near the neck region in stored bulbs, causing damage during the storage period. Reports from New Zealand (Monty Spencer, personal communication) indicate that longer neck length after topping helped lower thrips injury.

Materials and Methods

The treatment area was marked out of a commercial onion field. The treatments were in a latin square design with five treatments and five replications. The plot size was two beds wide by 15 ft in length. All treatments were made on September 12, after which 20 bulbs from each plot were harvested and placed into mesh bags made of "no-thrips insect screen". This material has a mesh size of 81 x 81 with a hole opening size of 0.0059 x 0.0059 inches and a thread size of 0.15 mm. The treatments were:

- 1-inch neck left on onion
- 3-inch neck left on onion
- 3-inch neck plus Warrior insecticide treatment after topping
- 3-inch neck plus Lannate and MSR insecticide treatment after topping
- 5-inch neck left on onion

After harvest the onions were placed into commercial onion storage at McCain Foods. Storage conditions were the same as used for commercial onions.

The onions were removed from storage on March 28, warmed for 2 days, and evaluated for thrips damage and decay on March 30.

Results and Discussion

There were no observed thrips on any of the onions. There was scarring around the neck region of the bulbs and this was scored on a scale of 0-10 with 0 meaning no damage and 10 being completely scarred. Black mold was the principle decay organism present and it was evaluated for severity with 0 equaling no disease present and 10 being completely decayed.

Table 1. Evaluation of stored Spanish onions for thrips damage and disease severity. Ontario, OR. 2001.

Treatment	Thrips Damage	Black Mold Severity
1-inch neck length	3.0	11.6
3-inch neck length	3.2	6.8
3-inch neck length + Warrior	1.4	7.6
3-inch neck length + Lannate + MSR	1.4	6.8
5-inch neck length	2.4	5.4
LSD (0.05)	1.2	n.s.

The insecticide treatments of Warrior or Lannate plus MSR resulted in significantly less thrips damage than the other treatments. Neck length did not influence thrips damage.

Although there was a trend towards less black mold with increasing neck length, this was not statistically significant.

MICRO-IRRIGATION ALTERNATIVES FOR HYBRID POPLAR PRODUCTION, 2001 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 2001. 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 of -50 kPa for initiating irrigations. Reducing the water application rate at each irrigation from 2 inches to 1.54 or 0.77 inches 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 with a water application rate of 2 inches and the drip-irrigated treatments with rates of 1.54 and 0.77 inches in terms of height, DBH, or stem volume annual increment. Irrigating at -50 kPa and applying 2 inches at each irrigation with microsprinklers or 1.54 inches with two drip tapes required 34 and 36 acre-inch/acre of applied water plus rainfall in 2001, respectively. Water use efficiency was higher with drip irrigation than with microsprinklers.

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 *Populus nigra*) performs well on alkaline soils for at least 6 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 objective of this study was to evaluate poplar water requirements in the fifth year and to compare microsprinkler irrigation to drip irrigation.

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 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.

In March 2000 the field was divided into 20 plots, each of which was 6 tree rows wide and 7 trees long. The plots were allocated to five treatments arranged in a randomized complete block design and replicated four times (Table 1). The microsprinkler irrigation treatments used the existing irrigation system. For the drip-irrigation treatments, either one or two drip tapes (Nelson Pathfinder, Nelson Irrigation Corp., Walla Walla, WA) were laid on the surface 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 GMS 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., Inc.). 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). All plots in the three microsprinkler-irrigated treatments were irrigated whenever the SWP at 8-inch depth for treatment 1 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-inch, 20-inch, 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-inch, 20-inch, and 32-inch depths, respectively.

Leaf tissue analyses to monitor and correct nutrient deficiencies during the season consisted of a composite sample of the first fully developed leaf from the central canopy from each of the five middle trees in the middle row of all plots in the wettest sprinkler-irrigated treatment.

2000 Procedures
The side branches on the bottom 6 ft of the tree trunk had been pruned from all trees in February, 1999. In March of 2000, another 3 ft of trunk were pruned, resulting in 9 ft of pruned trunk. The pruned branches were flailed on the ground and the ground between the tree rows was disked on April 12. On April 24, Prowl at 3.3 lb ai/acre was broadcast for weed control. The field was irrigated using the existing microsprinkler system with an application of 0.7 inches 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 disked on April 12. On April 13, Prowl at 3.3 lb ai/acre was broadcast for weed control. The field was irrigated applying 0.8 inches 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.

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. 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). Annual growth increments for height, DBH, and stem volume for 2001 were calculated as the difference in the respective parameter between October 2000 and October 2001.

Results and Discussion

The microsprinkler-irrigated treatment with 2 inches of water applied at each irrigation consumed 34 acre-inch/acre of water in 20 irrigations (Table 1). The drip treatment with 1.54 inches of water applied through 2 tapes consumed 36 acre-inch/acre applied in 19 irrigations. The drip treatment with 0.77 inches of water applied through 1 tape consumed only 25 acre-inch/acre in 28 irrigations.

In November 2001 (5th year), trees in the wettest sprinkler-irrigated treatment averaged 40 ft in height, 6.8 in DBH, and 788 ft^3 of stem volume (Table 1).

For the microsprinkler-irrigated treatments, the highest annual increment in DBH and stem volume was achieved with a water application rate of 2 inches (Table 2). The annual increment in tree height was not significantly different between the sprinkler-irrigation treatments. There was no significant difference between the microsprinkler-irrigated treatment with a water application rate of 2 inches and either of the drip-irrigated treatments in terms of height and stem volume annual increment. Drip irrigation with two tapes per tree row (water application rate of 1.54 inches) resulted in the highest DBH increment. Using one drip tape instead of two per tree row resulted in a reduction in DBH increment, but did not result in a significant reduction in stem volume increment, in spite of the large statistically significant difference in water applied, 25 acre-inch/acre vs. 36 acre-inch/acre.

There were positive linear relationships, with similar slopes, between total water applied and stem volume increment 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. Reducing water applications with the microsprinkler system resulted in a substantial reduction in water use efficiency, in contrast to the drip system, probably reflecting the higher proportionate evaporative losses from the soil surface following shallow irrigations with the microsprinkler system (Table 1).

The soil water potential 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 soil water potential among the two drip treatments and the sprinkler treatment with 2 inches of water application rate. The soil water potential 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 volumetric soil water content at 8-inch depth over time and averaged over the season (Table 3) was highest for the drip plots and decreased with the reductions in water application rate in the sprinkler treatments. At 18-inch depth the soil water content was highest for the drip treatments. At 30-inch depth, the differences between treatments were smaller and only sprinkler treatment 2 had a lower soil water content than the drip treatments. The soil water content in the drip treatments oscillated with a higher amplitude than the sprinkler plots, especially at 18-inch and 30-inch depths, reflecting the much smaller application area than the sprinkler plots.

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

Treatment	Irrigation threshold	Water application depth	Irrigation system	Total number of irrigations	Total water applied*	Water use efficiency
	kPa †	inch per application			acre-inch/acre	ft^3 of wood/acre-inch
1	-50	2	Microsprinkler	18	34.3	7.0
2	coincide with trt #1	1.54	Microsprinkler	18	27.2	4.7
3	coincide with trt #1	0.77	Microsprinkler	18	15.4	5.3
4	-50	1.54	Drip, 2 tubes	19	35.8	8.0
5	-50	0.77	Drip, 1 tube	28	25.2	9.7
LSD (0.05)				1	3.8	3.6

*Includes 1.43 inches of precipitation from May through September.
†Soil water potential at eight-inch depth.

Table 2. Height, diameter at breast height (DBH) and stem volume measurements in early November 2001 and 2001 growth increments for hybrid poplars submitted to five irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR.

Treatment	November 2001 measurements			2001 growth increment		
	Height	DBH	Stem volume	Height	DBH	Stem volume
	ft	inch	ft^3/acre	ft	inch	ft^3/acre
1	40.2	6.8	787.6	3.6	0.86	245.2
2	33.8	5.9	485.2	2	0.64	116.6
3	30.0	4.3	299.1	3.2	0.58	110
4	38.6	6.6	737.8	5.1	1.07	294.4
5	38.0	6.4	667.5	5.8	0.87	254.7
LSD (0.05)	6.9	0.5	200.5	3	0.19	119.8

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

Treatment	Average soil water potential			Average volumetric soil water content		
	1st ft	2nd ft	3rd ft	1st ft	2nd ft	3rd ft
	--------------- kPa ---------------			--------------- % ---------------		
1	-34	-43	-72	15.8	12.5	13.4
2	-54	-88	-99	12.9	10.4	9.9
3	-119	-91	-103	9.0	12.5	12.9
4	-26	-28	-41	20.6	15.6	15.2
5	-32	-42	-40	17.5	14.4	15.6
LSD (0.05)	-18	-30	-50	2.1	2.6	4.2

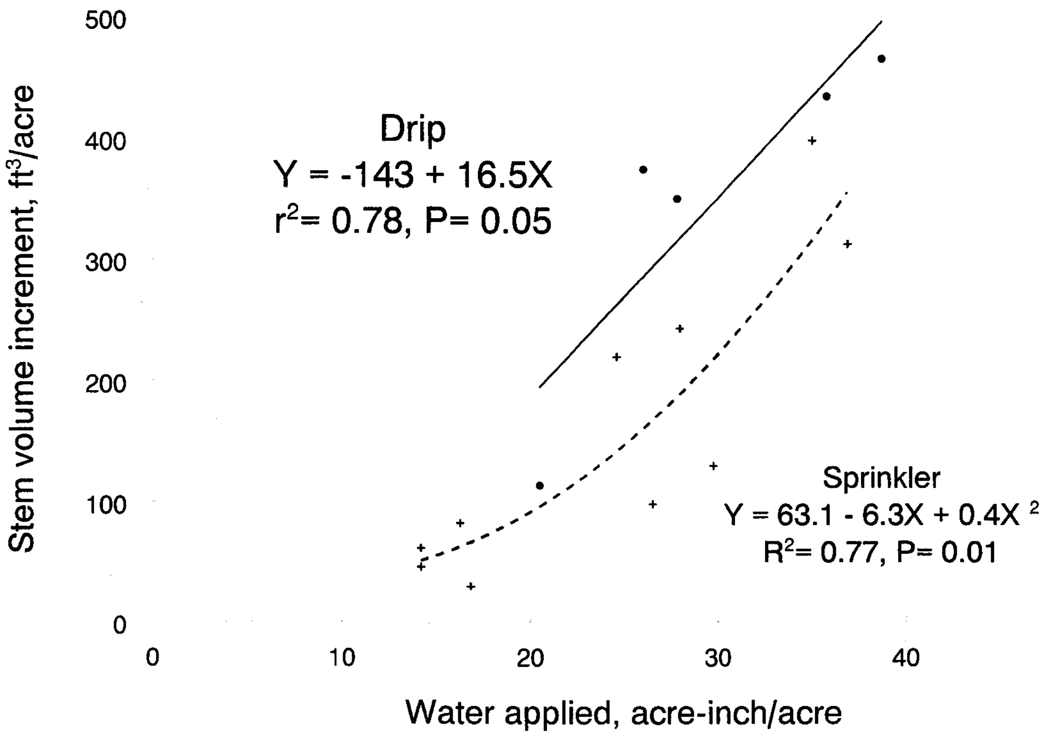

Figure 1. Response of stem volume increment to water applied for hybrid poplar using microsprinkler and drip irrigation. Malheur Experiment Station, Oregon State University, Ontario, OR.

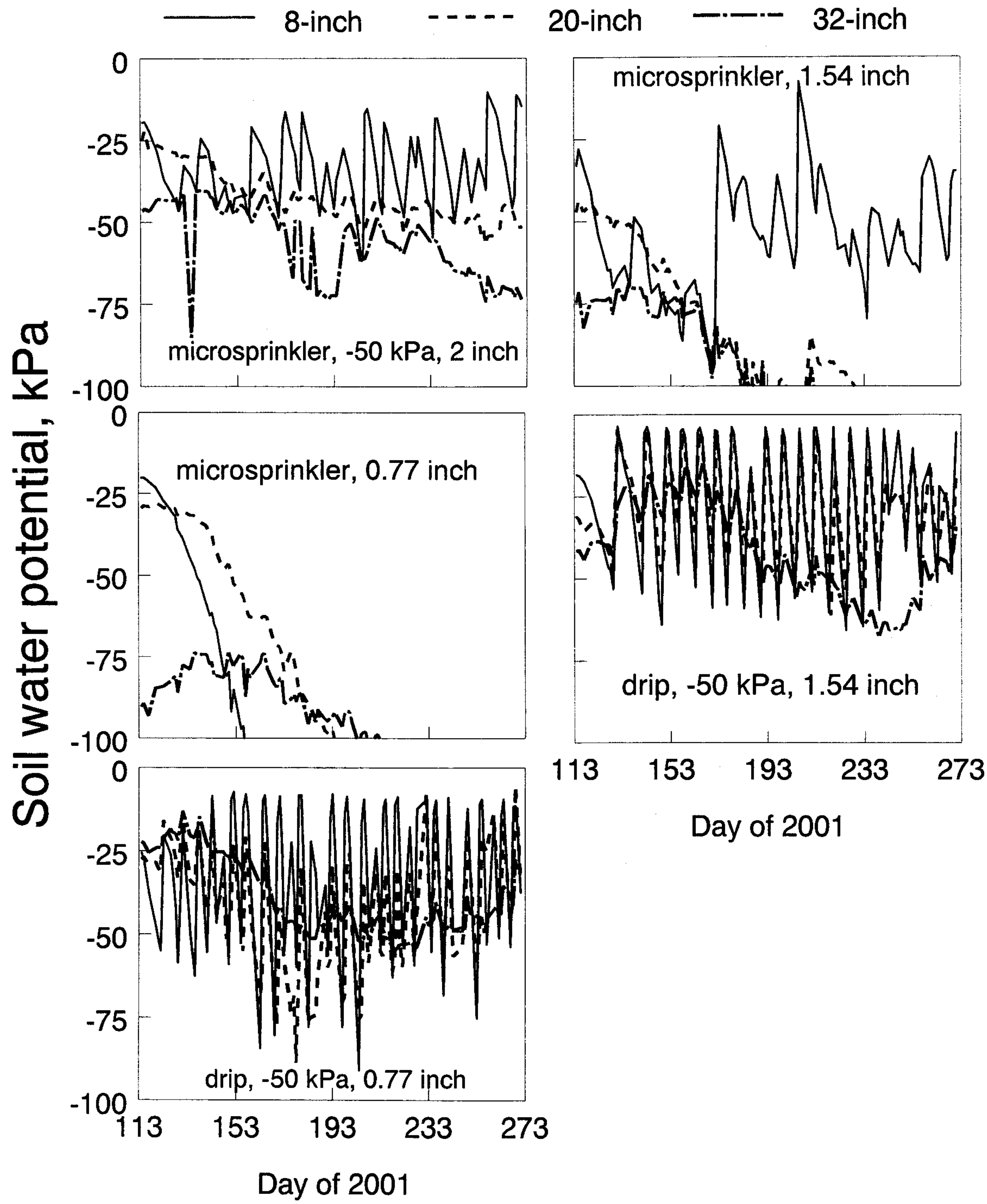

Figure 2. Soil water potential at three depths using granular matrix sensors in a poplar stand submitted to five irrigation regimes. Malheur Experiment Station, Oregon State University, Ontario, OR.

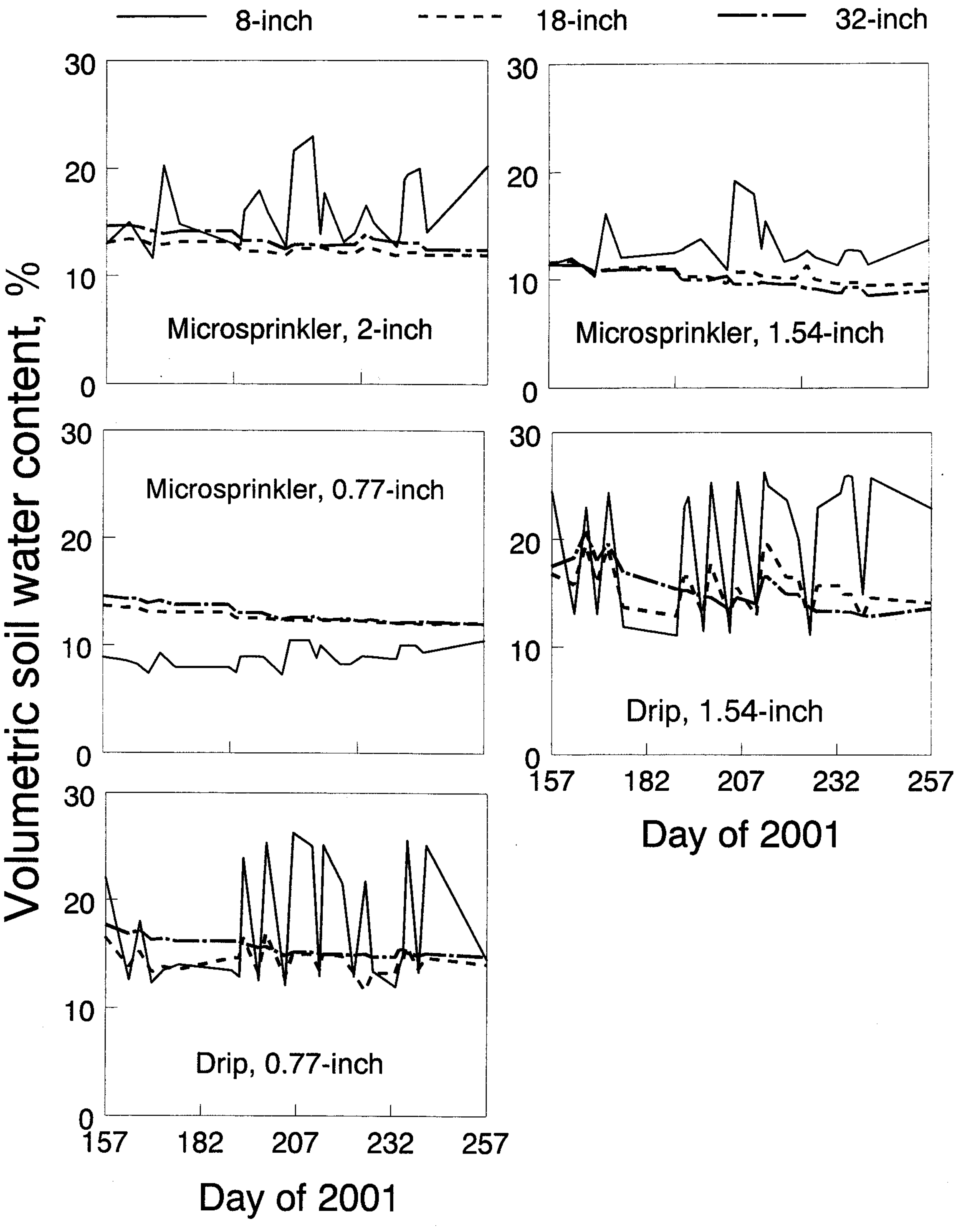

Figure 3. Soil water content at three depths using neutron probe in a poplar stand submitted to five irrigation regimes. Malheur Experiment Station, Oregon State University, Ontario, OR.

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 was submitted to five pruning treatments. Pruning treatments consisted of the rate at which the side branches were removed from the tree to achieve an 18-ft branch-free stem. Starting with a 6-ft (from ground) pruned stem, the 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 9, 12, or 15 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. Another treatment compares the effect of pruning during tree dormancy to pruning after growth has resumed. In 2001 the treatments ranged in pruning severity from 17 to 45 percent of total tree height. Stem volume growth in 2001 was not affected by pruning up to 24 percent of the total tree height for trees undamaged by leafhoppers. Leafhopper damage exacerbated the negative effects of pruning on tree growth.

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 Populus nigra*) performs well on alkaline soils for at least 4 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 their value as saw logs and peeler logs. The amount of live crown removed in 1 year 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 sprouting 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 8.2 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. 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 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 3 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 report.

For the pruning study, only plots in the two wetter microsprinkler-irrigated treatments and the drip irrigated treatments were used. The middle two rows in each irrigation plot were assigned to pruning treatment 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 and March 14, 2001. Trees in treatment 5 were pruned on May 16, 2000 and May 21, 2001. 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).

In 1999, a leafhopper infestation in part of the field resulted in damage to the terminal shoots, resulting in the tree canopy having a bushy or witches-broom appearance by the end of the season in 1999. The leafhoppers were controlled in 2000 and 2001, but damage symptoms persisted through 2001. Since tree growth response to pruning could be influenced by the leafhopper damage, all trees were rated for the degree of damage. Leafhopper damage was evaluated subjectively as the degree to which the tree canopy had a witches-broom appearance (flat top) as opposed to a more conical shape in undamaged trees. Leafhopper damage was evaluated in October each year.

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 diameter at breast height (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) 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 2001 were calculated as the difference in the respective parameter between October 2000 and October 2001. Growth increments for the combined 2000 and 2001 seasons were calculated as the difference in the respective parameter between October 1999 and October 2001. Regression analyses for the effects of leafhopper damage on tree growth were run for damaged and undamaged trees separately. 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

The percentage of the total height pruned in 2001 for trees undamaged by leafhopper feeding averaged from 15 percent for the check treatment to 39 percent for treatment 4 (Table 1). The percentage of the total height pruned in 2001 for trees damaged by leafhopper feeding averaged from 20 percent for the check treatment to 55 percent for treatment 4.

Height increment in 2001 and 2000-2001 for the trees undamaged by leafhoppers was not very responsive to pruning. (Fig. 1 and 2). Diameter at breast height increment for the undamaged trees showed a negative linear response to pruning severity (Fig. 1 and 2). Calculated from the regression equations, stem volume increment for the undamaged trees was not reduced until the height pruned exceeded 24 percent of total height in 2001 and 2000-2001. Future monitoring of tree growth will help determine whether, once pruning ceases, stem volume increments for pruned trees would approach that of unpruned trees.

Leafhopper damage exacerbated the negative effects of pruning on tree growth. Height increment for the damaged trees in 2001 was not responsive to pruning (Fig. 1). Height increment for the damaged trees in 2000-2001 showed a negative response to pruning severity (Fig. 2). Diameter at breast height increment for the undamaged and damaged trees showed similar negative linear responses to pruning severity. However, at the same pruning severity, DBH increment was smaller for the damaged trees than for the undamaged trees (Fig. 1 and 2).

While stem volume increment for the undamaged trees was reduced when pruning severity exceeded 24 percent of the total height, any level of pruning to the leafhopper damaged trees reduced stem volume increment.

The substantial effects of pruning severity on tree growth for the trees undamaged by leafhopper feeding contradicts the Oregon State University Extension recommendation to limit pruning to 50 percent of total height (Hibbs 1996).

Sprouting was substantially lower for the trees pruned in May than in March when the trees were dormant (Table 1). Pruning in May, after the trees had resumed growth, resulted in fewer sprouts, less total sprout weight, and less time to remove the sprouts.

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Table 1. Current and intended future poplar pruning trial treatments and actual percentage of total height pruned (percentage of total height that is branch-free stem after pruning) in 2001 for trees undamaged and damaged by leafhopper feeding. 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 stem height pruned		Number of sprouts	Sprout weight	Time to prune sprouts†
	1999	2000	2001	2002	2003	2004	undamaged	damaged	#/acre	lb/acre	hours/acre
1 Check	6	6	6	6	6	6	15.7	19.8			
2	6	6	9	12	15	18	22.9	31.6			
3	6	9	12	15	18	18	29.3	41.2	4,806	366.1	5.8
4	6	12	15	18	18	18	39.4	55.0			
5‡	6	9	12	15	18	18	31.5	39.1	739	24.5	1.0
LSD (0.05)							2.1	7.4	1,347	123.2	2.6

*Stem height to which all side branches were removed.
†One person.
‡ Pruned in May. All others pruned when trees were dormant.

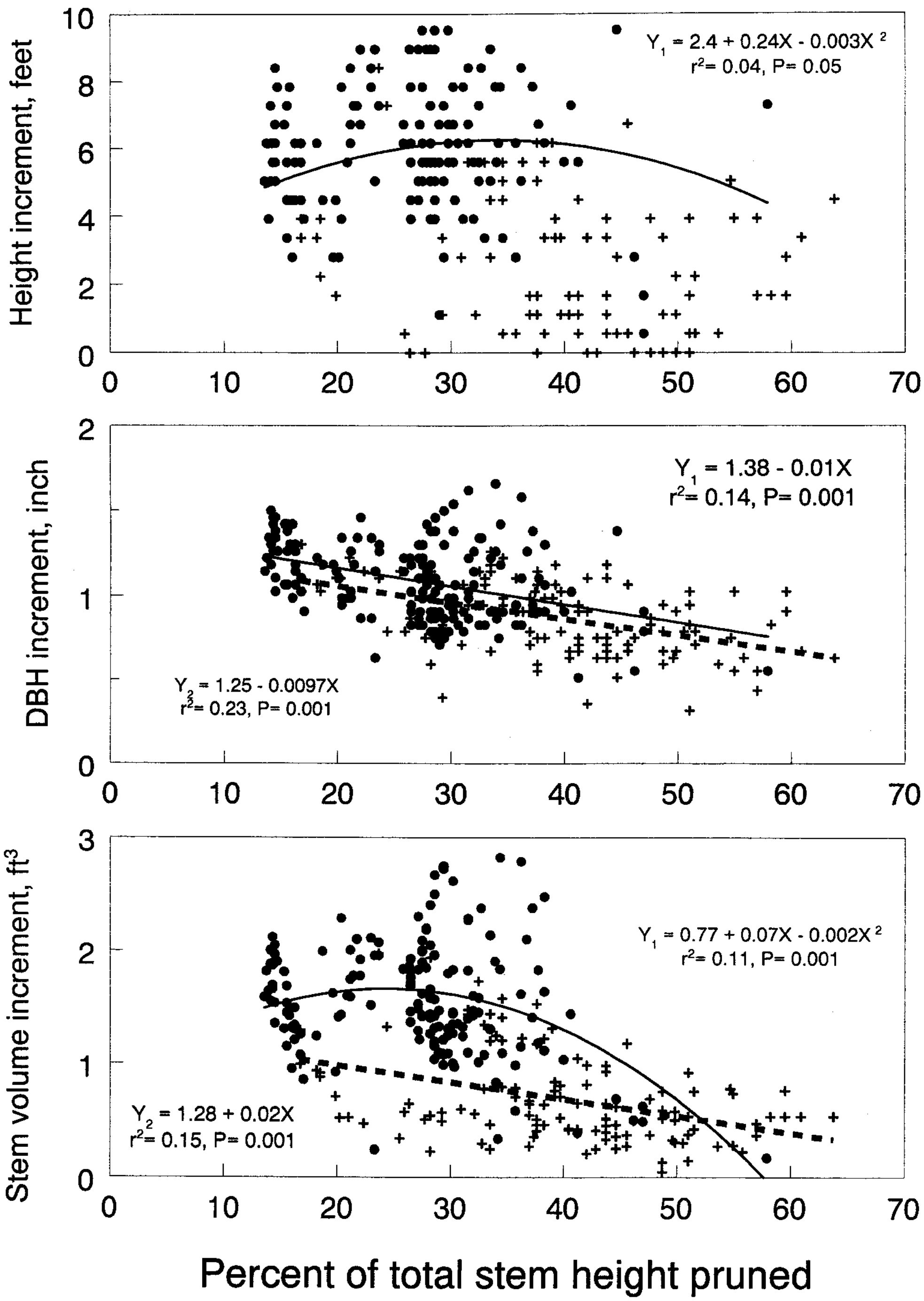

Figure 1. Poplar tree 2001 growth increment response to pruning severity for trees undamaged (Y_1, continuous line, •) and damaged (Y_2, dashed line, +) by leafhoppers. Malheur Experiment Station, Oregon State University, Ontario, OR.

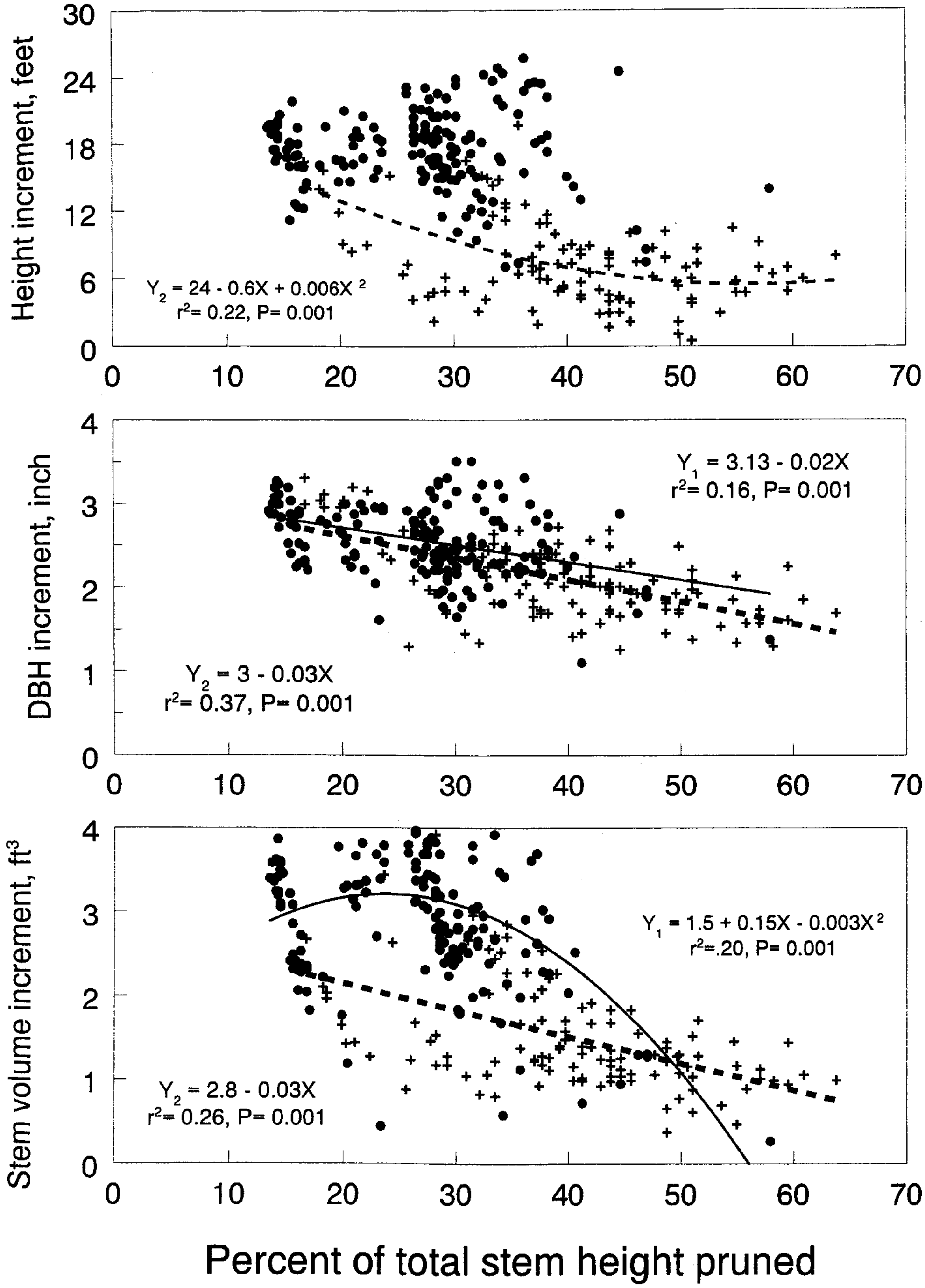

Figure 2. Poplar tree 2 year (2000-2001) growth increment response to pruning severity for trees undamaged (Y_1, continuous line, •) and damaged (Y_2, dashed line, +) by leafhoppers. Malheur Experiment Station, Oregon State University, Ontario, OR.

WILLOW SHARPSHOOTER STUNTING OF HYBRID POPLAR GROWTH

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Introduction

Over the last 5 years, the only insect pest that has been documented to cause significant damage to the hybrid poplar at the Malheur Experiment Station has been the willow sharpshooter (*Graphocephala confluens*, Uhler), a type of leafhopper. Willow sharpshooter was not known to be an economic pest of poplars. This report describes the impact of sharpshooter feeding on tree growth and our attempts at monitoring and control of the sharpshooter.

Materials and Methods

Willow Sharpshooter Observations and Control

Until 1999 the willow sharpshooter (leafhopper) was not observed in the trees. In late June of 1999 an infestation of leafhoppers was first observed in parts of the plantation. The population appeared to have peaked in early July. At the population peak the leafhopper numbers were such that when walking through the badly infested parts of the plantation the insects could be heard rustling in the tree canopy. The advice of a consultant who inspected the leafhopper infestation was that the trees tolerate the feeding and control was not necessary. After early July the population seemed to dwindle until late August, when large numbers of adults were again observed. The field was sprayed with Diazinon AG500 at 1 lb ai/ac on September 4. Leafhoppers were not observed when the plantation was checked on September 6.

In 2000, adult leafhopper numbers started increasing in mid-May. The field was sprayed aerially with Diazinon AG500 at 1 lb ai/ac on May 27. Leafhoppers were not observed when the plantation was checked 2 days later. In early July, adult numbers again started to increase. The field was sprayed with Warrior at 0.03 lb ai/acre on July 10. After the second insecticide application leafhoppers were not observed for the rest of the season.

During the 2001 season, three leafhopper sampling methods were tested. Sampling methods were (1) aerial sweeps of the tree canopy using a large net with 15-ft extension handle, (2) visual inspections of foliage on the sprouts (sucker growth) from the lower trunk, and, (3) use of yellow sticky traps suspended from the lower branches of the tree canopy. All sampling methods were replicated and conducted on a weekly basis from April 1 through mid-July during the 2001 growing season. The sticky traps were used to monitor the adult leafhopper population. Aerial net and leaf observations recorded both adult and nymphal population levels of the leafhopper. Sampling and observed population trends assisted in timing of insecticide treatments.

Tree Production Practices

The trees were grown 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. Hybrid poplar sticks, cultivar OP-367, were planted on April 25, 1997 on a 14-ft by 14-ft spacing.

In 1999, the 2 year old trees were irrigated with a microsprinkler system (R-5, Nelson Irrigation, Walla Walla, WA) 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. Plots were three rows wide and seven trees long.

In 2000 and 2001, the trees were irrigated either with the microsprinkler system or with a drip-irrigation system. Two drip tapes (Nelson Pathfinder, Nelson Irrigation Corp., Walla Walla, WA) were laid along the tree row. The two drip tapes were 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. The trees were irrigated when the soil water potential at 8-inch depth reached -50 kPa. The microsprinkler-irrigated trees had 2 acre inches of water applied at each irrigation and the drip-irrigated trees had 1.54 acre inches of water applied at each irrigation. Irrigations were run from May through September each year. Plots were six rows wide and seven trees long.

Soil water potential (SWP) was measured by granular matrix sensors (GMS; Watermark Soil Moisture Sensors model 200SS; Irrometer Co. Inc., Riverside, CA) at 8-inch depth. The GMS were installed along the tree row and between risers and trees. The GMS were previously calibrated (Shock et al. 1998) and were read at 8:00 a.m. daily starting in May, the starting date for the irrigation treatments.

Tree Growth Measurements

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 in early May 1999, and in early October each year. Annual growth increments for height and DBH were calculated as the difference in the respective parameter between October of the current year and October of the previous year. Annual growth increments for 1999 were calculated as the difference in the respective parameter between October 1999 and May 1999. By the end of the season in 1999, leafhopper feeding caused the death of terminal shoots of trees in the affected parts of the plantation. The death of the terminal shoots resulted in the loss of apical dominance, causing the tree to grow in a bushy way, with a flat top and a witches'-broom appearance. Trees in the undamaged parts of the plantation retained the normal conical canopy shape. Leafhopper damage was evaluated subjectively as the degree to which the tree canopy deviated from a conical appearance (0 = no damage, 10 = maximum damage). Leafhopper damage was evaluated in October each year.

Results and Discussion

Tree Growth

Tree height increments decreased with increasing leafhopper damage in all years (Fig. 1 to 3). Diameter at breast height increment decreased with increasing leafhopper damage in 2000 and 2001 (Fig. 1 to 3). In 1999 DBH increment was not affected by leafhopper damage. Tree heights in October 2001 were lower for trees with higher leafhopper damage (Fig. 4). Diameter at breast height in October 2001 was not correlated with leafhopper damage (Fig. 4). Damaged trees retained the witches'-broom appearance and had dead terminal shoots through 2001.

Reductions in tree growth from leafhopper damage are probably largely due to the 1999 damage; the percentage of trees with a damage level greater than 0 remained stable through 2001. The percentage of damaged trees was 41, 30, and 45 percent in 1999, 2000, and 2001, respectively. Also, the average subjective damage level remained stable through 2001. The average subjective damage levels were 3.3, 0.74, and 1.8 in 1999, 2000, and 2001, respectively. In addition, the more timely control measures in 2000 and 2001 did not allow the leafhopper populations to build up to the 1999 level. The tree damage symptoms are persistent despite the improved leafhopper control. The trees could be infected with Pierce's disease, which is known to be transmitted to many plant species by other species of leafhopper.

Monitoring

Of the three leafhopper sampling methods the yellow sticky traps appeared most useful in detecting adult leafhopper population trends. The numbers peaked on May 29 and June 6 with average adults per weekly trap collection at 16 and 17 leafhoppers, respectively (Fig. 5). The aerial net sweep samples only recovered trace levels throughout the sample period. Observations of the leaves on water sprouts (epicormic sprouts) detected a hatch of small leafhopper nymphs, which coincided with the trap catch peak of June 6. Aerial application of Warrior insecticide at 0.03 lb ai/acre occurred on June 11. Control was excellent and only a few leafhoppers were observed during the remaining sampling period through July 31. No additional infestations occurred during the 2001 season. Although the aerial net counts were low during the 2001 season, the timely and effective insecticide treatment may have prevented the leafhopper population from increasing as observed in 1999. Aerial sampling might have caught adult leafhoppers as they spread to the upper tree canopy in 1999.

Under the conditions of this study it appears that yellow sticky traps may be a useful sampling tool to predict population trends of adult leafhoppers in poplar tree plantations. They may help forecast the first nymphal hatch and help effectively time insecticide applications. Careful monitoring of the leafhopper in 2001 resulted in one aerial insecticide application for control. Two applications were made in 2000.

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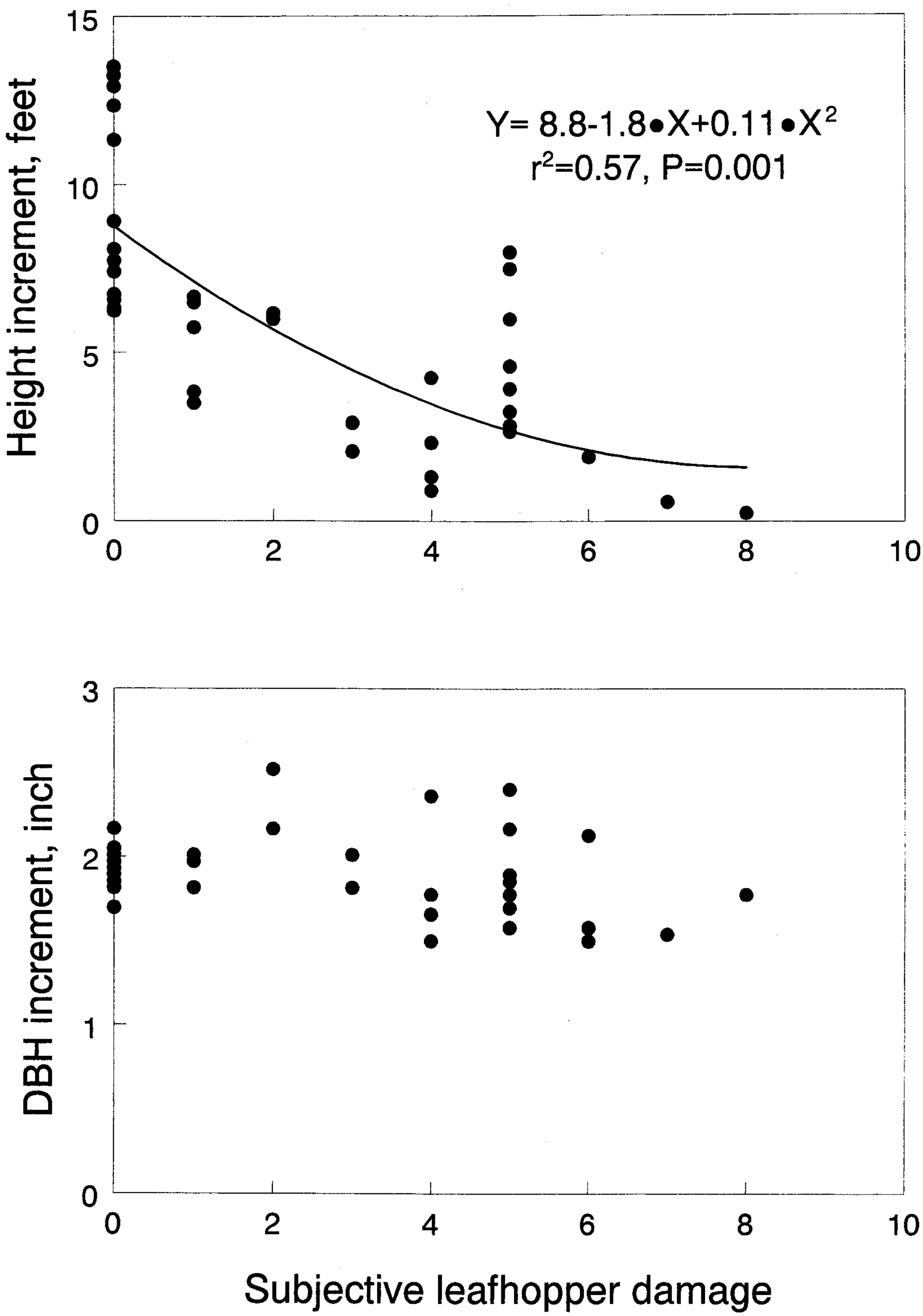

Figure 1. Relationship between the subjective evaluation of leafhopper damage (0 = no damage, 10 = maximum damage) on hybrid poplar in 1999 and tree growth increments during 1999. Malheur Experiment Station, Oregon State University, Ontario, OR.

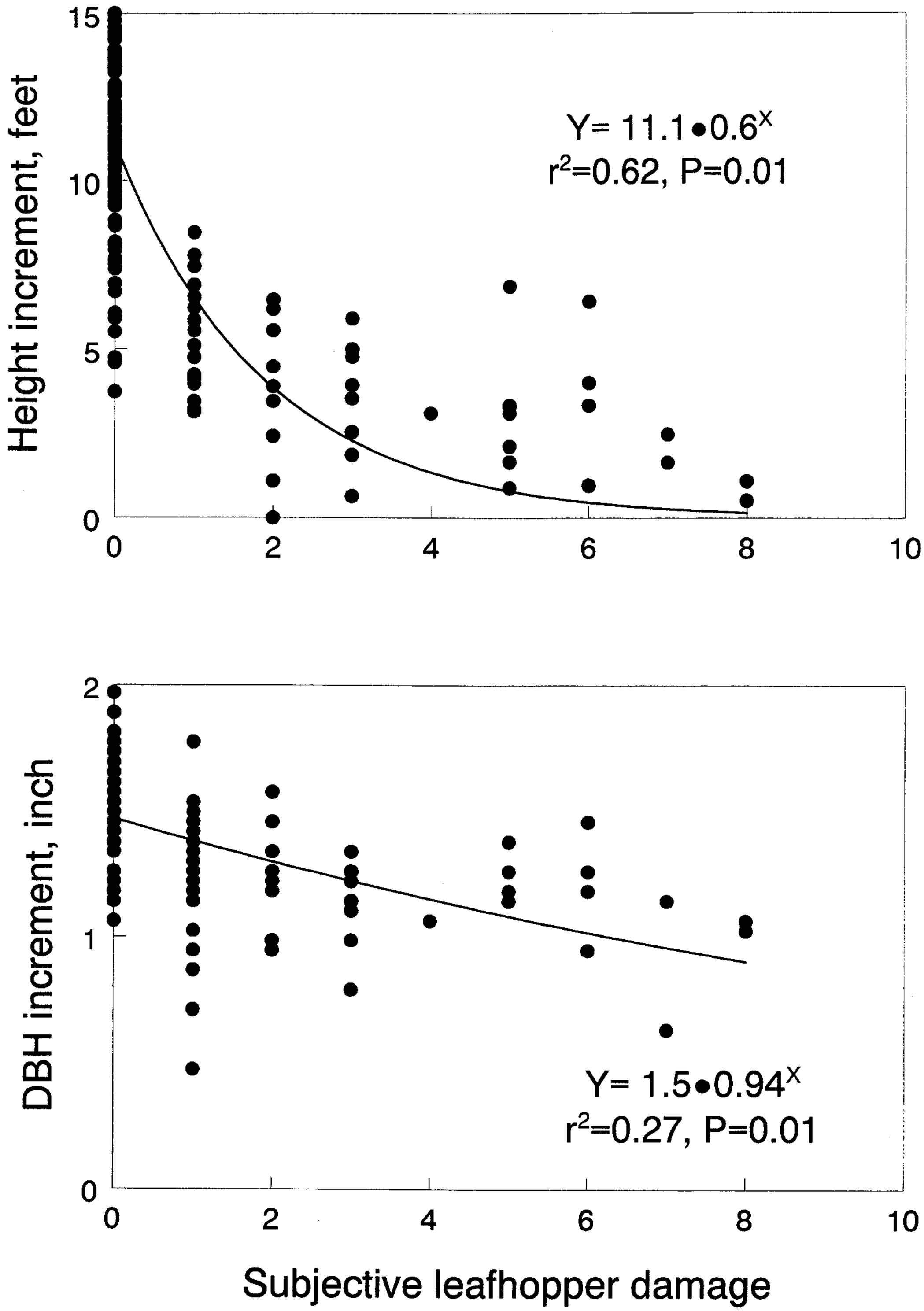

Figure 2. Relationship between the subjective evaluation of leafhopper damage (0 = no damage, 10 = maximum damage) on hybrid poplar in 2000 and tree growth increments during 2000. Malheur Experiment Station, Oregon State University, Ontario, OR.

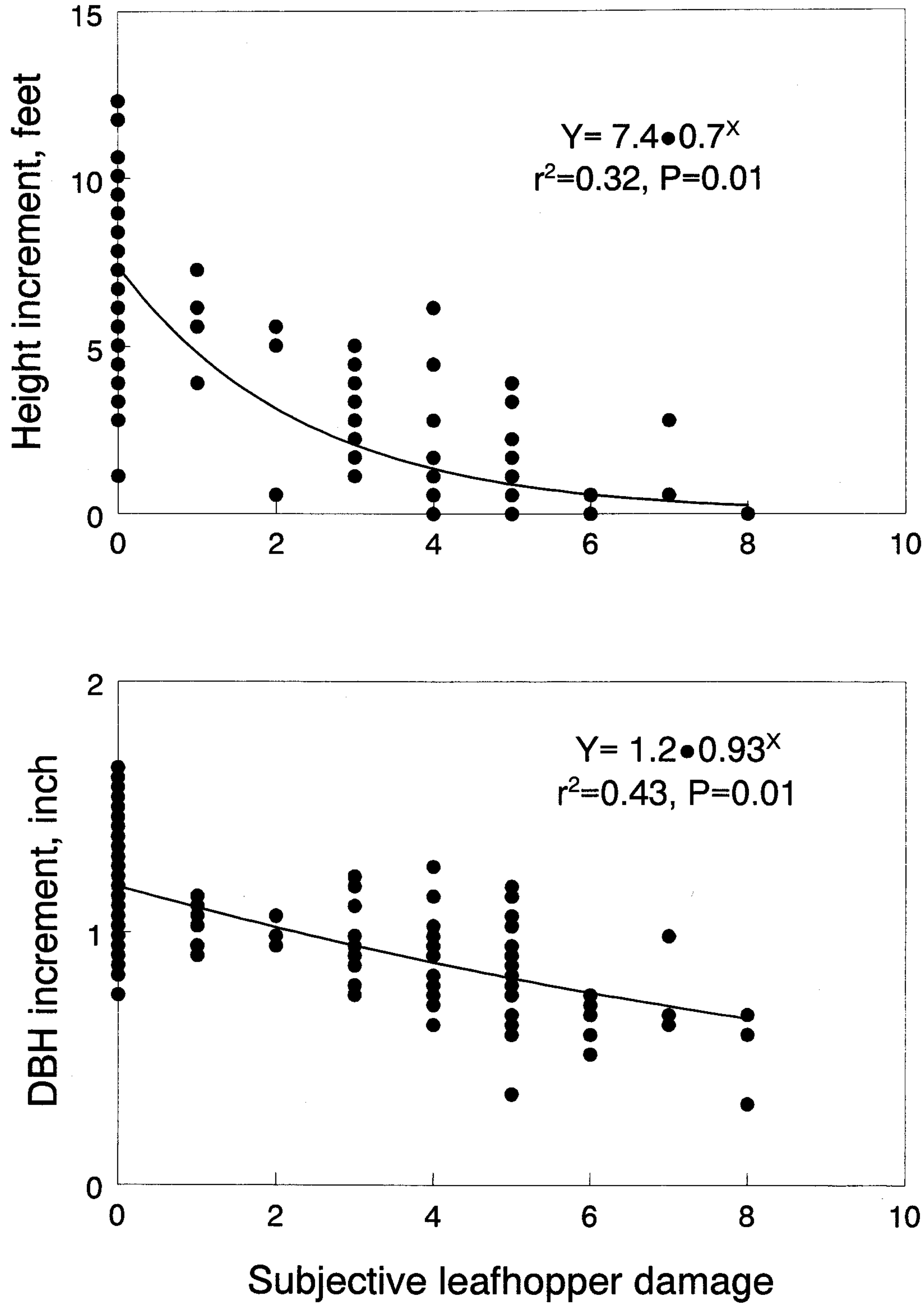

Figure 3. Relationship between the subjective evaluation of leafhopper damage (0 = no damage, 10 = maximum damage) on hybrid poplar in 2001 and tree growth increments during 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

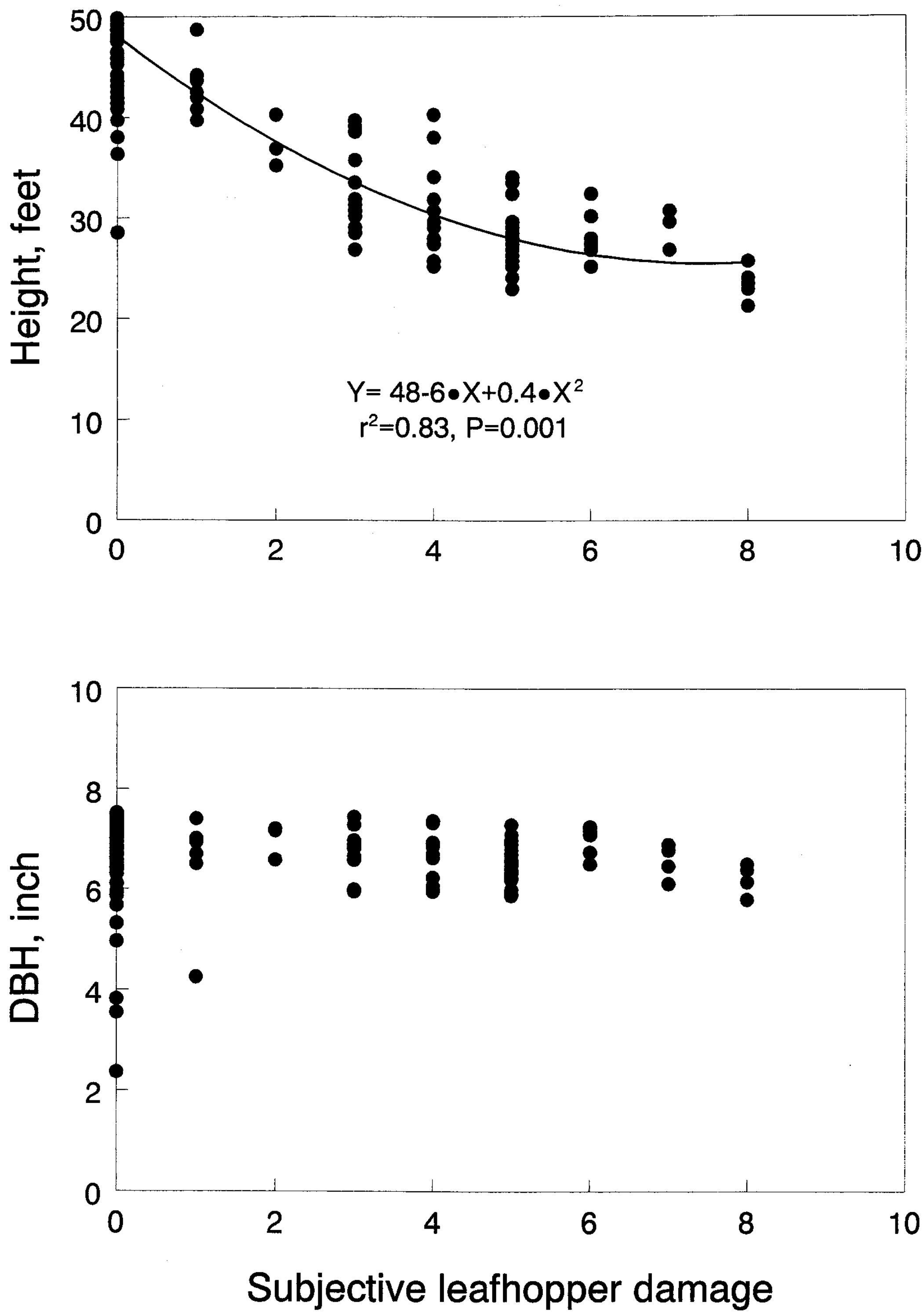

Figure 4. Relationship between the subjective evaluation of leafhopper damage (0 = no damage, 10 = maximum damage) on hybrid poplar in 2001 and tree height and DBH in October, 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

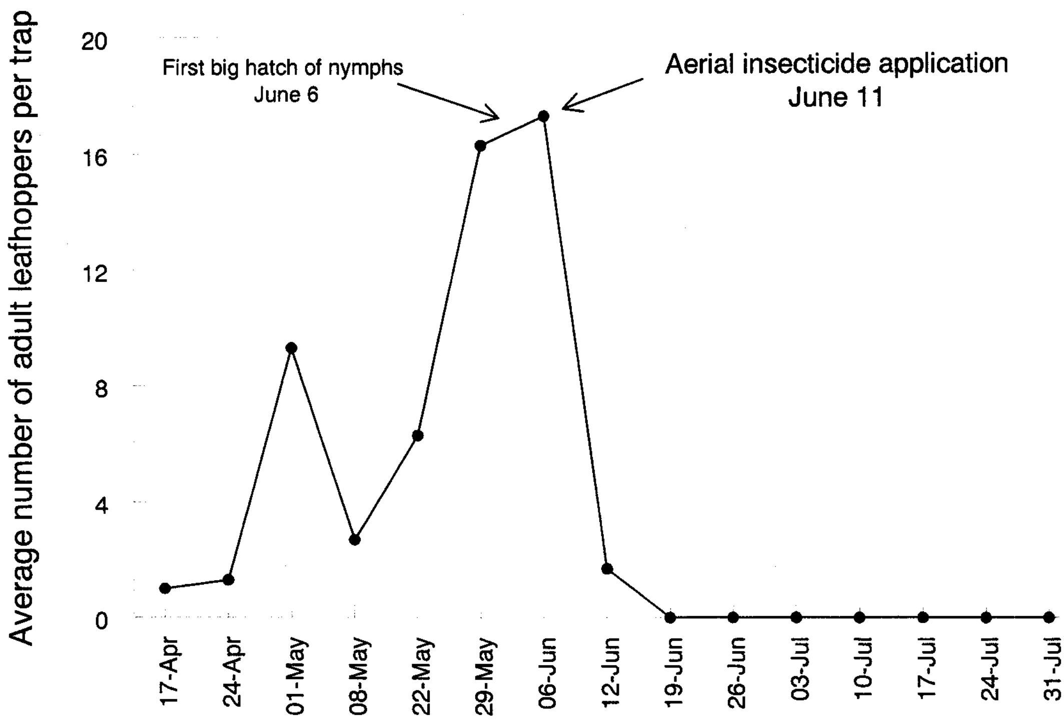

Figure 5. Average number of adult leafhoppers in insect yellow sticky traps in a hybrid poplar plantation in 2001. Malheur Experiment Station, Oregon State University, Ontario, OR.

THE WILLOW SHARPSHOOTER *GRAPHOCEPHALA CONFLUENS* (UHLER), A NEW PEST IN POPLAR TREE PLANTATIONS

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Introduction

Poplar tree plantings are being explored as an alternative forest products commodity in the Treasure Valley of eastern Oregon and southwestern Idaho. Damaging infestations of a species of leafhopper, Homoptera: Cicadellidae, were observed in a poplar tree plantation (hybrid of *Populus deltoides x Populus nigra*) located at Oregon State University (OSU) Malheur Experiment Station (MES) during the 1999-2001 growing seasons. 1999 was the third growing season of the trees and first year of the observed infestation by this new pest. The damaging impacts of the insect were underestimated and the infestation was not treated until September 4. The high population densities and feeding by the insects injured leaf buds and caused noticeable stunting of tree branch terminals and whole trees during 1999 growth cycle. In 2000 the leafhoppers were detected and treated much earlier in the season. Residual stunting of trees was observed even through the 2001 season from the previous year's insect activity. During all 3 years leafhopper outbreaks were treated at least once per season with aerially applied insecticides. Commercial poplar growers in the western Treasure Valley also reported observing and treating for leafhopper infestations over the last 3 years. The purpose of this study was to identify the species of cicadellids. The outbreak of this insect and its potential pest status in commercial poplar tree plantations have not been previously reported in the Pacific Northwest.

Methods

In May 2000 insects were collected and sent first to the OSU Department of Entomology and then forwarded to the USDA, Agricultural Research Service Systematic Entomology Laboratory (ARS SEL) in Washington D.C. Stuart McKamey of the ARS SEL made the species determination.

Results

The leafhopper was identified by ARS SEL as *Graphocephala confluens* (Uhler). The unofficial common name designation is the Willow Sharpshooter (WS). A literature search resulted in very few papers that mention this species and virtually no information about the species' pest status in poplar trees. Hardy (1942) observed this insect, using the synonym *Cicadella hieroglyphica var.confluens* (Uhler), "as a nuisance due to abundance" to the residence of White Swan, Washington. He goes on to describe the probable host for the insect as willow trees in a nearby riparian habitat. More recently *G. confluens* (syn. *Neokolla confluens)* has been implicated as a vector of plant pathogens including Pierce's disease (Frazier and Freitag 1946, Wolfe 1955, Purcell 1980). The possible existence of a leafhopper vectored plant pathogen infecting the poplar trees and contributing to the observed symptoms in the plantation is currently under study.

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VEGETABLE SOYBEAN (EDAMAME) PERFORMANCE AT ONTARIO IN 2001

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Introduction

Interest in the production and export of green vegetable soybeans (edamame) has grown in the Pacific Northwest. Soybeans for edamame are harvested at the large green bean stage and the pods can then be sold fresh or frozen. The pods are boiled for a few minutes and then shelled by hand at the table and consumed as a snack. Vegetable soybeans are sweeter and less beany tasting than grain soybeans. As the crop is harvested at the green bean stage, a shorter growing season is required than for conventional dry beans or soybeans as an oil seed crop. Four vegetable soybean cultivars were evaluated for their performance in eastern Oregon in 2001.

Methods

The trial was conducted on a silt loam previously planted to onion. Fifty lb of N, 100 lb of P, 55 lb of K, 55 lb of S, 28 lb of Mg, 1.8 lb of Zn, and 1.2 lb of Cu were broadcast in the fall of 2000. The field was then disked twice, moldboard plowed, groundhogged twice and bedded to 22-inch rows. Seed of the four cultivars was planted on May 18 at 120,000 seeds/acre in rows 22 inches apart. *Rhizobium japonicum* soil implant inoculant was applied in the seed furrow at planting. Micro-Tech herbicide at 1.5 lbs ai/ac was sprayed on May 19. The field was furrow irrigated as necessary. Plots were four rows wide and 22 ft long and were arranged in a randomized complete block design with four replicates.

Plant height and reproductive stage were measured every week for each cultivar. When a cultivar reached the green bean stage, bean samples from the border rows were dried in an oven to determine moisture content. Three ft of the middle two rows in each plot were harvested when the bean moisture content for a variety reached 70 percent. Plants were cut at ground level and measured for total weight and pod weight. A subsample of pods was weighed, and the subsample was divided into pods with two or more beans, pods with one bean, and cull pods. Marketable pods contain one or more beans. The pods in each category were weighed. The pods with two or more beans were shelled and the beans weighed and oven dried for moisture content determination. Pods with two or more beans are the most desirable.

Results and Discussion

The optimum plant population for edamame is 60,000 to 70,000 plants per acre (Miles et al. 2000). Plant populations were close to the optimum range for all varieties except 'Shironomai' (Table 1). There was no significant difference between varieties in either total pod yield or marketable pod yield. 'Sayamusume' had among the highest percentage of pods with two or more beans. Bean moisture at harvest was close to the target of 70 percent for all varieties.

References

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Table 1. Characteristics of four vegetable soybean cultivars (edamame). Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Cultivar	Source*	Plant population	Height	Days to green bean harvest†	Pod to whole plant ratio	Pod yield	Marketable pod yield	Two or more bean pods	One bean pod	Culls	Green bean moisture
		plants/acre	cm			--- lb/acre ---		-------- % by weight --------			
Kenko	1	74,227	80	103	0.30	13,912	10,065	24.3	47.6	26.3	69.3
Lucky Lion	2	77,848	65	103	0.31	15,130	11,373	27.3	48.2	24.3	68.5
Sayamusume	3	73,322	75	98	0.40	17,804	13,967	51.0	26.1	21.2	70.6
Shironomai	4	22,630	78	98	0.41	12,644	10,528	41.8	41.3	14.5	71.3
LSD (0.05)		24,966			0.01	NS	NS	17.3	7.2	NS	1.4

*Seed sources: 1 = Seedex, Inc., Longmont , CO; 2 = American Takii, Salinas, CA; 3 = Snow Brand Seed, Chiba City, Japan; 4 = Sakata Seed America Inc., Morgan Hill, CA.

†From emergence.

SOYBEAN PERFORMANCE IN ONTARIO IN 2001

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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 in 1994 and 1995. This report summarizes work done in 2001 as part of the continuing breeding and selection program to adapt soybeans to eastern Oregon.

Methods

The trial was conducted on a silt loam previously planted to onion. Fifty lb of N, 100 lb of P, 55 lb of K, 55 lb of S, 28 lb of Mg, 1.8 lb of Zn, and 1.2 lb of Cu were broadcast in the fall of 2000. The field was then disked twice, moldboard plowed, groundhogged twice and bedded to 22-inch rows. Seed of 8 single plant selections made in 1992, 18 single plant selections made in 1999, and 7 commercial cultivars was planted on May 18 at 200,000 seeds/acre in rows 22 inches apart. Seed was treated with ApronMaxx fungicide. *Rhizobium japonicum* soil implant inoculant was applied in the seed furrow at planting. Micro-Tech herbicide at 1.5 lbs ai/ac was sprayed on May 19. Emergence started on May 24. The field was furrow irrigated as necessary. Plots were four rows wide and 22 ft long. The experimental design was a randomized complete block with four replicates.

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 4 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. Data were analyzed by analysis of variance. Means separation was determined by the protected least significant difference test.

Results and Discussion

Yields ranged from 22 bu/acre for 'Evans' to 56 bu/acre for 'M16' and 'Korada' (Table 1). All cultivars had seed counts sufficient for the manufacturing of tofu (<2,270 seeds/lb) in 2001. All of the single plant selections made in Madras, Oregon, except 'M9' and 'M13', had lodging of 5 or more. Seven of the 1992 single plant selections had seed counts sufficient for the manufacturing of tofu (<2,270) averaged over 5 years (Table 2). The cultivars 'M92-330', 'OR-8', 'Evans', and 'Sibley' had seed counts of less than 2,270 seeds per lb every year that seed counts were made. The lines 'M92-225' and 'M92-237' made reasonable tofu in food quality tests in 1999.

Plant populations were below the target of 300,000 plants per acre in 1996 and 1997 and the target of 200,000 plants per acre in 1999, 2000, and 2001 (Table 4).

Table 1. Performance of soybean cultivars, Malheur Experiment Station, Oregon State University, Ontario, OR.

Cultivar	Days to maturity*	Days to harvest maturity*	Plant population	Lodging	Shatter	Height	Yield	Seed count
			plants/acre	0-10	percent	cm	bu/acre	seeds/lb
M92-085	104	125	77,848	3	0	90	49.8	1873
M92-213	104	125	83,280	0	0	70	28.7	1702
M92-220	119	131	77,848	2	0	83	47.2	2126
M92-225	96	119	65,175	0	0	80	42.6	2126
M92-237	104	119	71,512	5	0	90	47.8	2196
M92-314	104	125	94,142	0	0	83	42.2	2046
M92-330	104	119	89,616	1	0	90	52.2	1799
M92-350	104	125	84,185	6	0	86	46.2	2126
OR-6	104	125	84,185	9	0	71	43.6	2126
OR-8	119	131	90,521	9	0	88	24.9	1799
Evans	119	131	84,185	9	0	86	22.0	2037
Gnome 85	119	131	89,616	7	0	85	26.2	1955
Korada	104	119	89,616	4	0	92	56.0	1993
Lambert	119	131	105,005	8	0	90	38.6	2081
Sibley	104	136	91,426	8	0	91	29.3	1766
M1	104	125	85,995	5	0	90	49.8	1918
M2	104	125	126,730	5	0	97	52.1	1873
M3	104	125	96,858	4	0	81	45.9	1993
M4	104	125	102,289	5	0	88	50.3	1993
M5	104	125	95,953	6	0	85	50.3	1873
M6	96	119	92,332	5	0	80	41.8	1911
M7	104	125	124,919	7	0	81	44.7	1911
M8	96	125	113,152	7	0	81	42.7	2081
M9	104	119	66,986	3	0	86	52.0	1799
M10	104	125	85,995	6	0	87	44.0	1955
M11	104	125	81,469	6	0	94	48.3	1911
M12	104	125	93,237	5	0	82	54.6	1911
M13	104	125	107,720	3	0	88	48.7	1993
M14	104	119	86,900	5	0	87	39.3	1898
M15	104	125	107,720	7	0	90	48.0	1948
M16	104	125	119,488	4	0	93	56.4	2000
M17	104	125	86,900	6	0	89	39.9	1918
M18	104	125	124,014	6	0	80	52.7	1993
LSD (0.05)			29,955	3			8.9	127

*Days from emergence.

Cultivars M92-085 through M92-350 are from single plant selections made at the Malheur Experiment Station in 1992. Cultivars M1 through M18 are from single plant selections made from M92-330 by Peter Sexton at the Central Oregon Agricultural Research and Extension Center in Madras, Oregon in 1999.

Table 2. Seed counts for soybean cultivars for 6 years, Malheur Experiment Station, Oregon State University, Ontario, OR.

Cultivar	1994	1995	1996	1999	2000	2001	average 1994-2000
				seeds/lb			
M92-085	2392	2188	2030	2455	2236	1873	2260
M92-213	2304	1995	2084	2284	2081	1702	2150
M92-217	1976	2033	2000	2149			2040
M92-220	2660	2213	1974	2336	2461	2126	2329
M92-223	2273	2017	1930	2456			2169
M92-225	2825	2353	2195	2169	2443	2126	2397
M92-237	2449	2142	2049	2547	2528	2196	2343
M92-239	2041	1946	2227	2346			2140
M92-314	2119	2113	1962	2302	2484	2046	2196
M92-330	2063	2037	2195	2113	2090	1799	2100
M92-350	2580	2219	2168	2218	2357	2126	2308
OR-6	2803	2205	1985	2327	2316	2126	2327
OR-8	2083	2059	2055	2223	1938	1799	2072
Agassiz	2372	2166	1984	2230	2335		2217
Evans	2232	2152	1972	2187	2180	2037	2145
Glacier				2309	2286		2298
Gnome 85	2463	2167	2040	2003	2174	1955	2169
Korada					2324	1993	2324
Lambert	2347	2126	1934	2270	2278	2081	2191
Lena					2373		2373
Minnato				3405			3405
Proto				2199			2199
R0725CH					2374		2374
Sibley	2066	1845	1828	2226	1847	1766	1962
Vinton				1759			1759
Mean	2336	2110	2034	2296	2269	1983	2209
LSD(0.05)		155	116	132	157		

Table 3. Yield of soybean cultivars in 8 years. Hail depressed yields in 1998. Malheur Experiment Station, Oregon State University, Ontario, OR.

Cultivar	Yield								
	1994	1995	1996	1997	1998	1999	2000	2001	Average 1994-2000
	bu/acre								
M92-085	63.3	48.7	41.2	50.0	29.4	48.6	48.2	49.8	47.1
M92-213	61.2	43.4	52.3	49.9	26.9	53.5	44.0	28.7	47.3
M92-217	35.7	49.3	48.8	55.2	25.3	47.7			43.7
M92-220	62.0	49.6	46.3	54.6	47.4	42.8	41.4	47.2	49.2
M92-223	45.6	55.3	34.5	45.5	20.9	39.9			40.3
M92-225	62.8	49.1	51.7	43.7	27.8	49.3	49.4	42.6	47.7
M92-237	63.1	50.6	42.1	48.5	31.9	44.8	48.1	47.8	47.0
M92-239	47.8	42.2	44.4	42.0	23.5	43.4			40.6
M92-314	63.2	48.9	57.8	49.2	28.6	47.5	39.3	42.2	47.8
M92-330	57.8	51.1	55.0	44.8	41.8	45.4	52.3	52.2	49.7
M92-350	63.6	55.2	43.0	49.9	34.9	42.4	47.7	46.2	48.1
OR-6	58.2	28.2	25.3	43.6	33.1	42.6	51.1	43.6	40.3
OR-8	66.3	34.0	22.1	34.2	13.6	40.1	37.1	24.9	35.3
Agassiz	62.4	36.3	38.6	46.0	21.7	43.9	48.0		42.4
Evans	68.6	13.2	14.2	29.9	25.0	40.0	47.5	22.0	34.1
Gnome 85	67.0	32.6	25.3	41.8	23.9	41.0	49.6	26.2	40.2
Lambert	69.6	31.7	29.4	53.6	35.2	47.5	57.1	38.6	46.3
Sibley	64.3	24.0	18.4	29.7	14.8	41.0	40.1	29.3	33.2
Average	60.1	41.3	38.4	45.1	28.1	44.5	46.7	38.7	43.5

Table 4. Plant population for soybean cultivars for 5 years, Malheur Experiment Station, Oregon State University, Ontario, OR.

	Plant population				
Cultivar	1996	1997	1999	2000	2001
	---------------------------------- plants/acre ----------------------------------				
M92-085	184,533	121,664	120,780	76,230	77,848
M92-213	155,587	139,769	143,550	78,210	83,280
M92-217	72,366	153,528	92,070		
M92-220	130,259	129,630	141,570	81,180	77,848
M92-223	47,038	115,870	148,500		
M92-225	57,893	134,699	141,570	76,230	65,175
M92-237	47,038	134,699	145,530	93,060	71,512
M92-239	123,022	142,665	137,610		
M92-314	155,587	144,114	100,980	77,220	94,142
M92-330	115,786	138,320	104,940	97,020	89,616
M92-350	173,678	137,596	132,660	62,370	84,185
OR-6	188,152	133,521	153,450	81,180	84,185
OR-8	159,205	132,527	164,340	99,990	90,521
Agassiz	155,587	118,767	111,870	72,270	
Evans	94,076	127,457	103,950	100,980	84,185
Glacier			179,190	73,260	
Gnome 85	126,641	118,767	124,740	105,930	89,616
Lambert	249,663	137,596	188,100	110,880	105,005
Minnato			288,090		
Proto			162.360		
Sibley	115,786	131,803	99,990	98,010	91,426
Vinton			149,490		
Korada				116,820	89,616
Lena				76,230	
R0725CH				87,120	
Mean	130,661	132,944	142,515	87,589	85,211
LSD(0.05)		NS	22,361	25,797	29,955

PREDICTING THE ONSET AND SEVERITY OF POTATO LATE BLIGHT IN OREGON

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Abstract

Growers were able to save on fungicide applications for late blight control during 2001. The 2001 season was not conducive to the development of late blight. Late blight was not predicted in 2001 at Klamath Falls, Tulelake, Culver, Madras, Ontario, Nyssa, or Adrian, and did not occur.

Eight 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

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. 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 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. Blitecast and other predictive models are being compared to the actual onset and development of late blight.

Blitecast has worked as a predictive model with the criteria of 90 percent relative humidity in the crop canopy. It is essential that instruments are monitoring field conditions from the beginning of potato emergence.

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.

According to Dr. Walter Stevenson of the University of Wisconsin, Wisconsin potato growers are using Blitecast to control blight while simultaneously saving considerably on fungicides. These economies are possible through the adequate prediction of late and early blight. Both university personnel and private consultants make predictions using Blitecast in Wisconsin. University of Wisconsin extension information is distributed through newsletters, e-mail, and the university web site, and this extension information depends on the forecasts. Economies of production realized in Wisconsin are now being made available to interested Oregon growers.

Objectives

1. Provide daily predictions of the risk of the expansion of potato late blight during the 2001 season in the Treasure Valley, Klamath Basin, and Central Oregon.

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 Blitecast 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 2000 and 2001 seasons, data were collected from stations in eight potato fields and several AgriMet weather stations. Each of the eight 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), 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 Blitecast, and those estimates were distributed via the station web site, e-mail, and fax. Various models were tested in 1999 and 2000, with special emphasis on Blitecast and late blight predictions using leaf wetness.

Results, Discussion, and Conclusions

Disease Development and Predictions

The 2001 season was not conducive to the development of late blight. Late blight was not predicted in 2001 at Klamath Falls, Tulelake, Culver, Madras, Ontario, Nyssa, or Adrian, and did not occur. Environmental conditions were favorable for the rapid spread of late blight at Malin in the Klamath Basin very late in the season but late blight was not present.

Treasure Valley

Infield data were collected from four stations in 1996 and 1997, and three stations in 1998, 1999, 2000, and 2001. Starting in 1996, access to late blight predictions and low cost fungicide recommendations has helped growers in the Treasure Valley to reduce fungicide costs and control late blight.

Environmental conditions at Ontario, Nyssa, and Adrian were particularly dry in 2000 and 2001. The estimated accumulated severity values did not pass 2 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 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. In 1998, 1999, 2000, and 2001 late blight was not predicted by Blitecast 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 collected data near Madras during 1998, 1999, 2000, and 2001. Conventional Blitecast did not predict late blight in 1997, 1998, 1999, 2000, or 2001 and the occurrence of late blight was not recorded. The air in potato canopies has been very dry at Culver (Fig. 3) and Madras (Fig. 4), resulting in low accumulation of severity values in recent years.

Willamette Valley
One station in 1997 and two stations in 1998 and 1999 monitored potato canopy conditions. Late blight occurred on potatoes and sprouted potatoes on a cull pile and in a commercial tomato planting before potatoes emerged in 1998. Consequently, late blight spores were being spread even before they could be produced on potato plants, causing early onset of late blight in the Willamette Valley in 1998. Blitecast rapidly accumulated severity values at Woodburn in 1998 as it had in 1997.

In 1999, Blitecast predicted late blight in the Willamette Valley very late in the season, in contrast to previous years, due to shorter duration of high relative humidity throughout the season. Blitecast predicted late blight on August 8 at Woodburn and August 11 at Sherwood, before late blight was found in commercial fields in late August. Due to little interest by Willamette Valley growers and a reduced budget in 2000 and 2001, Willamette Valley sites have not been monitored since 1999.

Klamath Basin
A single station was set up south of Klamath Falls in 1997, and three stations were used in 1998, 1999, 2000, and 2001. Severity values accumulated slowly in 2001 due to dry atmospheric conditions (Fig. 5). The severity index remained very low at Tulelake during the 1999, 2000, and 2001 seasons (Fig. 6). The duration of high humidity in 2001 caused the severity index to reach 14 at Henley during 2001, perhaps 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).

The severity index at Klamath Falls remained at zero during 2001 as it had in 1999, and 2000. In 1997, conventional Blitecast 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 by Blitecast on July 26. The Klamath Falls late blight epidemic in 1998 occurred later in August (Fig. 8).

Leaf wetness
Leaf wetness estimates were made at all sites starting in 1998 using Campbell Scientific Leaf Wetness Sensors 237LW (Campbell Scientific, Logan UT). The late blight severity values based on leaf wetness accumulated much more rapidly than the severity values based on relative humidity in the plant canopy because the duration of the wet periods proved to be longer than the periods of high relative humidity. Marked differences were recorded for accumulated severity values based on 90 percent relative humidity and the conventional Blitecast program as compared with the use of leaf-wetness data. Severity indices based on leaf wetness have had little association with the onset of late blight.

In conclusion, conventional Blitecast 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 5 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, Roy Hasebe, Rob Hibbs, Rod Blackman, Mike McVay, Dan Chin, and Jay Hoffman. Constructive suggestions by Mary Powelson, Ken Rykbost, Bob Witters, and Al Mosley have been appreciated greatly.

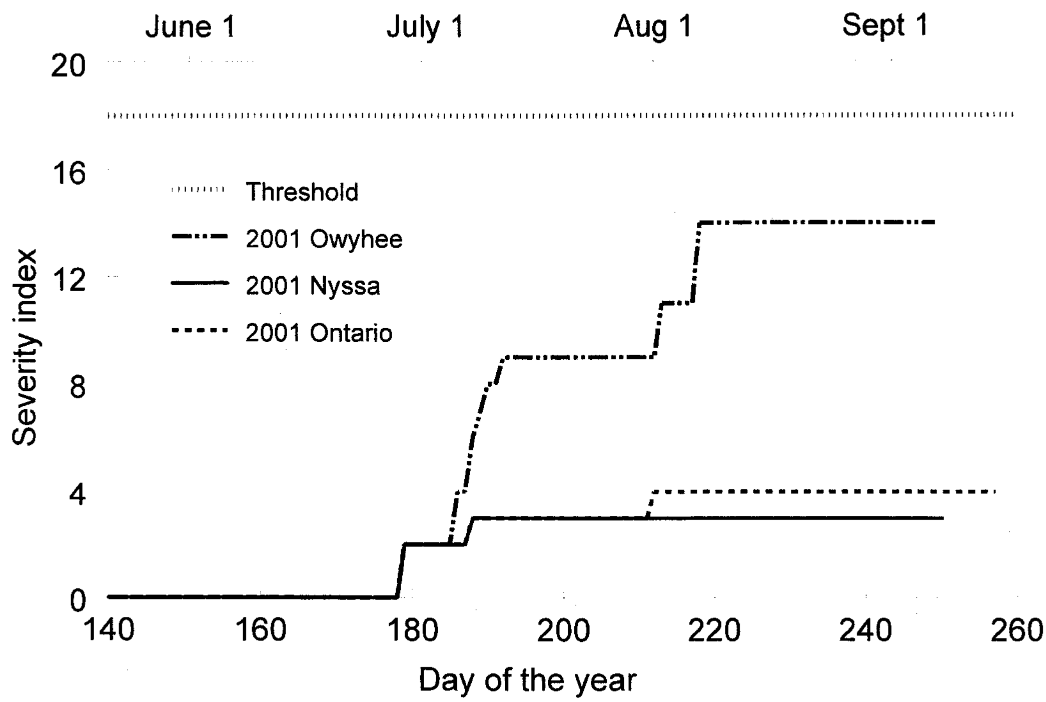

Figure 1. Comparison of three Treasure Valley locations (Ontario, Nyssa, and Owyhee Jct.) in the accumulation of estimated late blight risk during the 2001 season. Low relative humidity was associated with low accumulation of severity values; Malheur Experiment Station, Oregon State University, 2001.

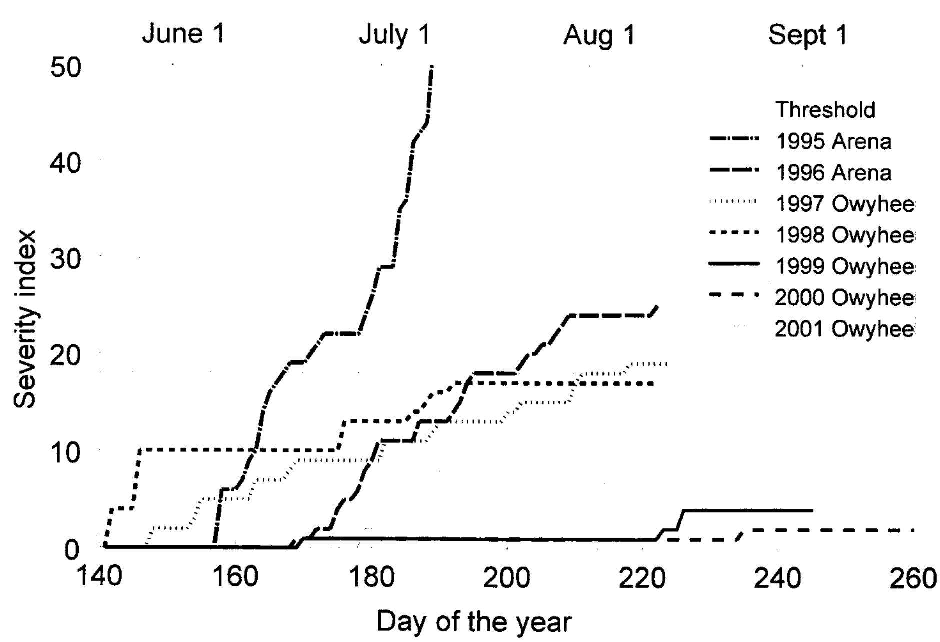

Figure 2. Comparison of late blight risk estimates over the last 7 years in the Treasure Valley. A severe late blight outbreak in 1995 was followed by a few late blight detections in 1996 and 1997. Late blight has not been detected the last 4 years; Malheur Experiment Station, Oregon State University, 2001.

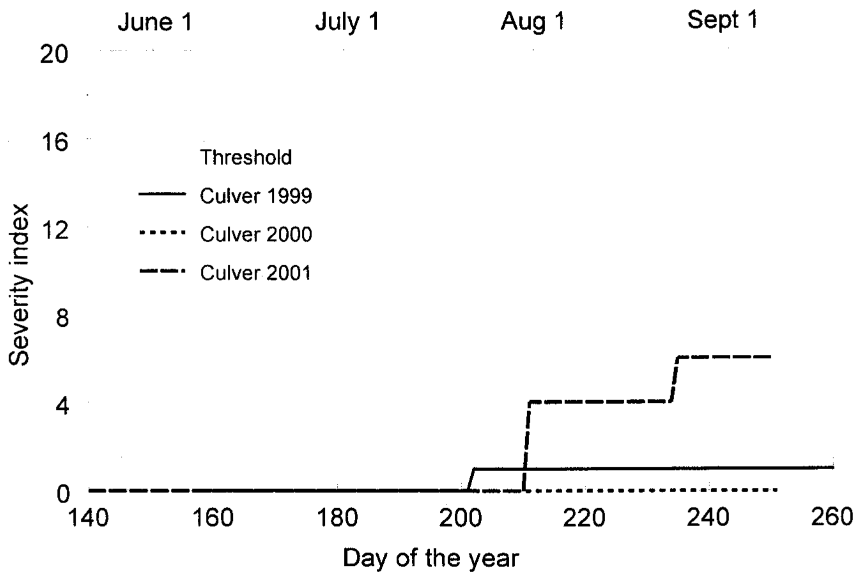

Figure 3. Accumulated severity values have remained low at Culver, Central Oregon during the last three seasons; Malheur Experiment Station, Oregon State University, 2001.

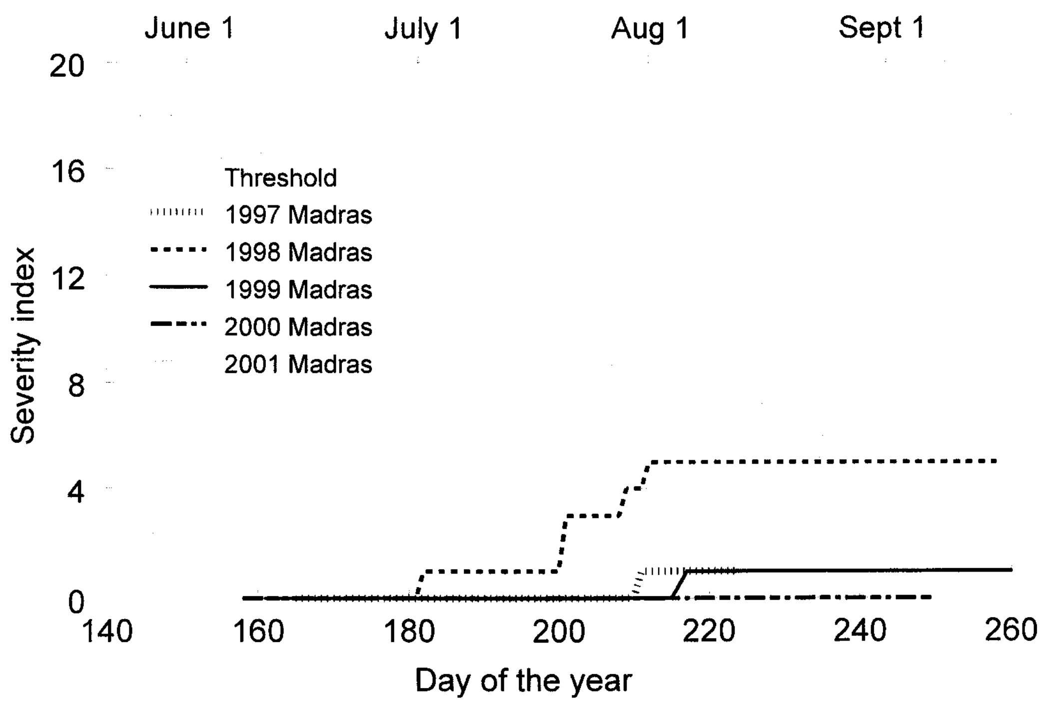

Figure 4. Accumulated severity values have also remained low the last five seasons at Madras in Central Oregon; Malheur Experiment Station, Oregon State University, 2001.

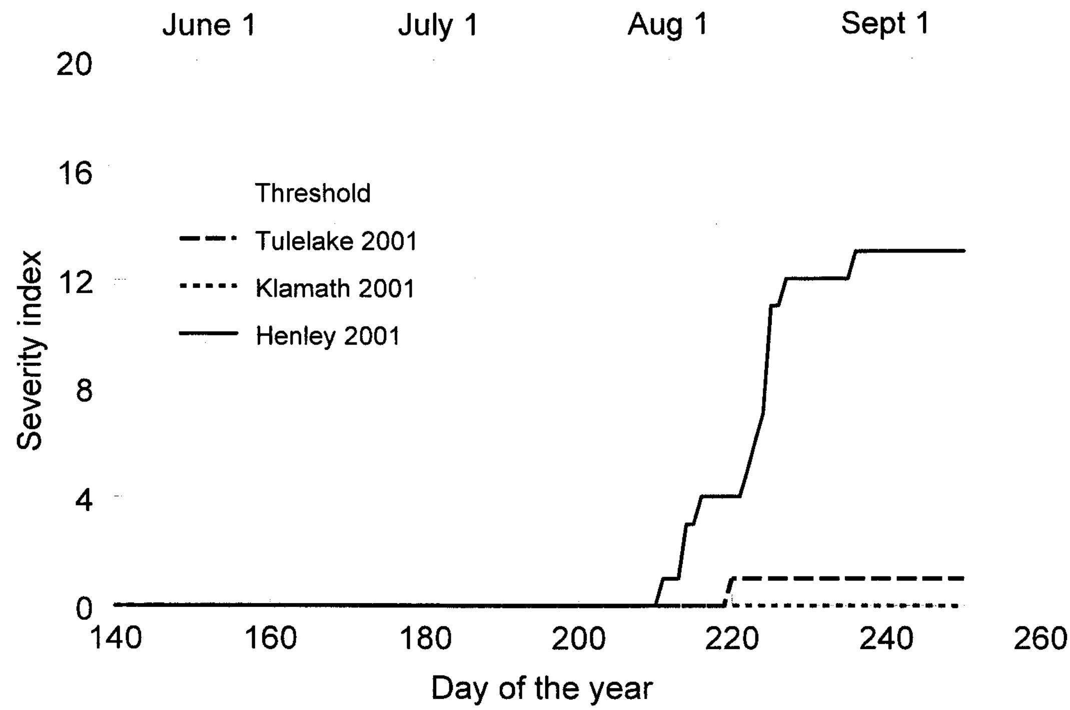

Figure 5. Comparison of three Klamath Basin locations in the accumulation of estimated late blight severity values during the 2001 season; Malheur Experiment Station, Oregon State University, 2001.

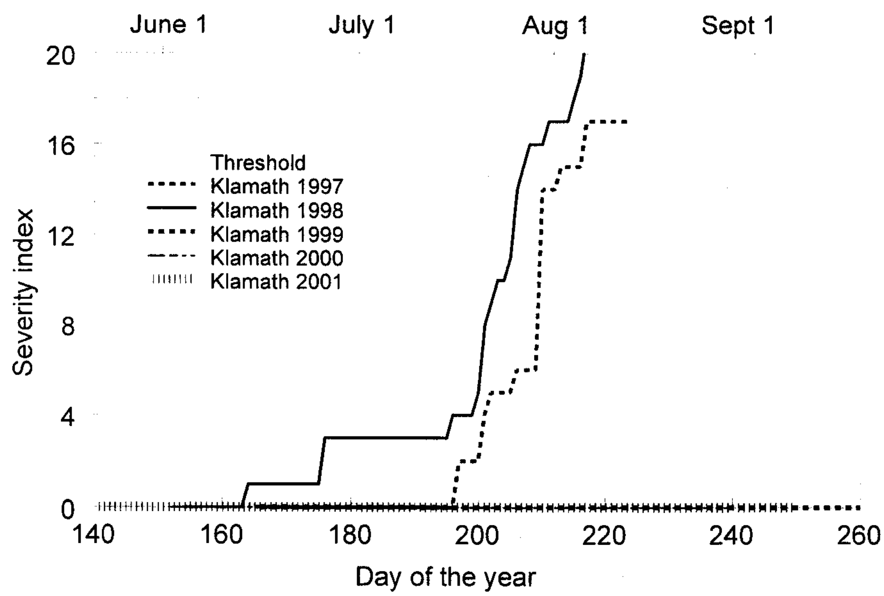

Figure 6. Comparison of late blight risk estimates over the last 5 years in the vicinity of Klamath Falls. Rapid accumulation of severity values in 1997 and 1998 was followed by losses to late blight. Risk estimates have not accumulated in 1999, 2000, or 2001; Malheur Experiment Station, Oregon State University, 2001.

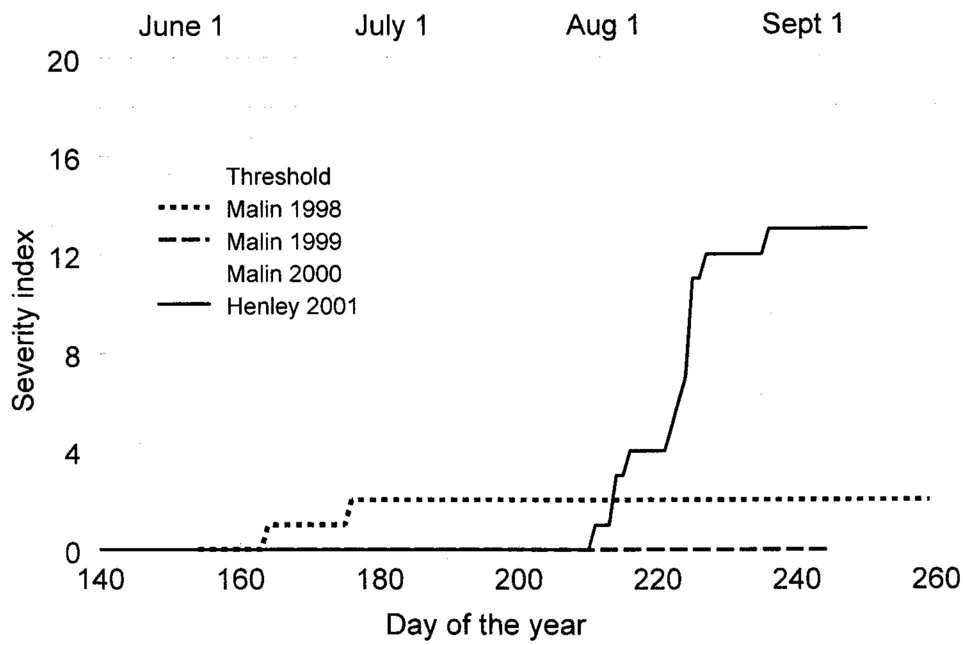

Figure 7. Comparison of the accumulation of estimated late blight severity values near Malin over the last 4 years. The severity index reached 18 at Malin only near the end of the 2000 growing cycle due to irrigation practices; Malheur Experiment Station, Oregon State University, 2001.

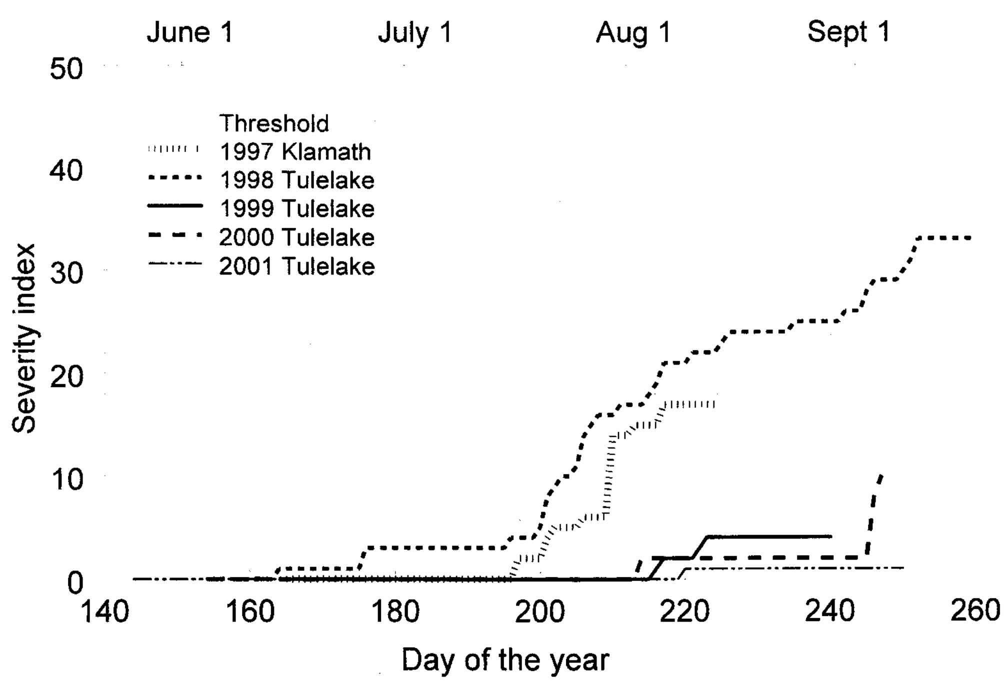

Figure 8. Comparison of late blight risk estimates over the last 5 years in the vicinity of Tulelake. Rapid accumulation of severity values in 1997 and 1998 was followed by losses to late blight; Malheur Experiment Station, Oregon State University, 2001.

DRIP IRRIGATION MANAGEMENT FACTORS FOR 'UMATILLA RUSSET' POTATO PRODUCTION

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Ontario, OR, 2001

Introduction

Water quality and water scarcity issues and may lead some growers to adopt drip irrigation for potato production. The objectives of this study were to investigate and document the performance of 'Umatilla Russet' under drip irrigation, and to explore the interaction of drip tape placement and irrigation criteria for potato crop production. It would be desirable to reduce the amount of drip tape used and to conserve water. This was the second year of testing 'Umatilla Russet' potatoes grown with variable irrigation criteria and drip tape placement.

Materials and Methods

The 2001 trial was conducted on Owyhee silt loam where winter wheat was the previous crop. The wheat stubble was flailed, the field was furrow irrigated and disked, then 50 lb N/acre and 100 lb P/acre were broadcast. In the fall, the field was ripped with Telone II injected at 22 gal/acre. The field was fall-bedded on 36-inch row spacing. A soil test taken on April 17, 2001 showed available nitrate plus ammonia totaled 68 lb N/acre in the top 2 ft of soil, 20 ppm extractable P, 272 ppm K, 1 percent organic matter, and pH 7.8.

Certified seed was hand cut into 2-oz seedpieces and treated with Tops-MZ-Gaucho dust. Potato seed was planted on April 19, 2001 using a Parma two-row cup planter (Parma Corp., Parma, ID) with the center furrowing shovel removed. Seedpiece spacing was 9 inches in the row, with rows 36 inches apart.

Prowl at 1 lb ai/acre plus Dual at 2 lb ai/acre, in 30 gal/acre spray mix, was applied on May 1 for weed control. The herbicides were incorporated with a spike-tooth bed harrow that formed a broad, flat-topped bed over the two potato rows. The toolbar at the back of the bed harrow had two wide shovels to lift soil out of the furrows, a spool of drip tape, and shanks to inject a single drip tape on the first pass, 2-3 inches deep in the center of the bed. A 16-ft length of 5/8-inch chain dragged in a “vee” from the shovel shanks pulled soil into the center of the bed. On the second pass with the bed harrow, in the opposite direction from the first pass, two drip tubes were injected 2-3 inches deep, directly over the two potato rows. The drip tape was 1000 Path (Nelson Irrigation, Walla Walla, WA), 8 mil thick, with 12-inch emitter spacing, and 0.22 gal/min/100 ft flow rate. In plots where one tape was to remain between the two potato rows, the outside two tapes were removed manually during the drip system installation. In the plots where a tape was over each row of potato plants, the center tape was removed manually during the drip system installation. Water was supplied to the drip tapes through 1/2-inch PVC pipe, with the five plots of each treatment fed by one valve. Matrix herbicide was applied preemergence at 1.2 oz/acre on May 7.

A complete factorial set of treatments was arranged in a randomized complete block design. Plots were two rows (6 ft) wide by 50 ft long. The first factor was either one drip tape between two potato rows, or two tapes (one tape over each row). The second factor was automated irrigation at -15, -30, -45 or -60 kPa soil water potential in the root zone measured with granular matrix sensors (GMS, Watermark Soil Moisture Sensors, Model 200SS, Irrometer Corp, Riverside, CA).

The four soil water potential levels and two tape placements were tested in all eight combinations in a randomized complete block design with five replicates. The GMS were installed between plants in the potato row, with three GMS per plot. Two GMS with the center of the sensor at 8-inch depth measured soil water potential for the irrigation criteria, and a third GMS, installed at 16-inch depth, monitored infiltration below the root zone.

The automated irrigation system read the soil moisture sensors in each plot every 6 hours, using multiplexers connected to a data logger (model CR10, Campbell Scientific, Logan, UT). If the average of the sensor readings from all five replicates of a treatment was less (drier) than that treatment's irrigation criterion, the irrigation valve to that treatment was opened. Plots with two tapes received a 1.5-hour irrigation, and plots with one tape received 3 hours of irrigation, so that each irrigation applied 0.1 inch regardless of the number of tapes. If the 0.1-inch irrigation did not sufficiently wet the soil to bring the sensor readings back above the criterion for a treatment, at the next 6-hour interval another irrigation would be applied. Water meters measured the volume of water applied to each treatment, and the meter readings were recorded daily.

All of the nitrogen fertilizer was injected through the drip tape. A 120-gal tank was used to hold a solution of 150 lb calcium nitrate dissolved in 111 gal of water by stirring with a paddle on an electric drill. The solution was metered into the irrigation water using a model A30-2.5 Dosmatic metering pump (Dosmatic USA International, Inc., Carrolltown, TX) at a rate of 1 gal of fertilizer solution to 500 gal of irrigation water. Fertilizer was injected to supply 50 ppm NO_3 in the drip irrigation water, beginning with the first irrigation on May 26.

Leaf petioles were monitored regularly to assure that plant nitrogen status remained in the ideal range for all treatments. On June 17 and 18, 11 lb N/acre, 8 lb S/acre, 0.17 lb Cu/A, and 0.21 lb Mn/acre were injected to correct deficiencies shown in the first petiole test, which was taken on June 11. From June 18 to July 16, dissolved calcium nitrate fertilizer was injected to maintain 50 ppm NO_3 in the drip system. On July 17 to 18, 10 lb S/acre, 5 lb Mg/acre, 0.25 lb Zn/acre, and 0.25 lb Mn/acre were injected to correct deficiencies shown in the third petiole test, taken on July 12. From July 18 to July 31, calcium nitrate solution was again injected at 50 ppm NO_3. Fertilizer was injected to supply 50 ppm NO_3 in the drip system from June 2 to July 10. On July 10 additional calcium nitrate was injected to bring the total applied N on all treatments to 140 lb N/acre. From July 11 to August 2 fertilizer solution was injected to maintain 50 ppm NO_3 in the drip system. From August 3 through the final irrigation on September 19, no fertilizer was injected.

Fungicide applications to prevent late blight infection consisted of an aerial application of Ridomil Gold and Bravo at 2 lb/acre on June 14, and then Dithane at 4 pint/acre on June 22. Powdered sulfur was applied at 30 lb/acre by aerial application on July 14 and again on July 28 to control powdery mildew.

The vines were flailed on September 19. Potatoes were lifted on October 1 with a two-row digger (John Deere, Moline, IL) that laid the tubers back onto the soil in each row. The drip tape was dug along with the potatoes. It fed over the two-row primary chain digger and was gathered by hand and tied in bundles for disposal. At harvest, the potatoes in each plot were visually evaluated for defects such as growth cracks, knobs, curved or irregularly shaped tubers, pointed ends, or stem end decay. A 5-ft alley was measured at the ends of each plot. All tubers from the interior 45 ft of each plot were placed into burlap sacks and hauled to a barn where they were kept under tarps until grading.

Tubers were graded October 24 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. Samples were removed from storage December 5-6, specific gravity was measured using the weight-in-air, weight-in-water method for 20 tubers, and 20 tubers/plot were cut lengthwise and center slices were fried for 3.5 min in 375°F soybean oil. Percent light reflectance was measured on the stem and bud ends of each fried 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.

Results and Discussion

Potatoes planted on April 19 did not fully emerge until May 20 due to cool-to-hot temperature fluctuations in April and May. Dry weather prevented late blight from developing in 2001. Precipitation for April through September was 2.13 inches.

2000 Drip Irrigation Management Factors Trial

Data for the 2000 trial are presented for comparison (Table 1). Yields in 2001 were generally higher than in 2000. In 2000 tuber specific gravity was influenced by the irrigation criteria and tape placement. There were more sugar ends in 2000, and lower percent of U.S. No. 1 tubers in 2000. The automated drip system applied more water than the AgriMet estimate of evapotranspiration (Et_c) to the treatments irrigated at -15 kPa with either one tape per row or one tape per two rows (Fig. 1).

2001 Tape Placement

The average total yield of all eight treatments was 582 cwt/acre, with a significantly higher total yield, 634 cwt/acre, with one tape for two rows (Table 2). Total U.S. No. One grade tubers was significantly higher with one tape per row. The yield of under 4-oz-tubers was significantly higher with a drip tape on every row. Treatments with a drip tape for every row of potato plants produced more tubers in the 6- to 12-oz grade, averaging 271 cwt/acre, compared to 168 cwt/acre with one tape for two rows. Conversely, the treatments with one tape for two rows produced 217 cwt/acre over 12 oz, compared to 129 cwt/acre for one tape for each row. A tape for each row also produced significantly less U.S. No. 2 grade tubers, with a significant interaction between the irrigation criterion and the drip tape.

2001 Soil Water Potential

Treatments with irrigation automated at -45 and -60 kPa yielded less than the -15 and -30 kPa treatments (Table 2). Yield of U.S. No. 1 grade tubers was significantly higher with the two wetter irrigation criteria. The -15 kPa treatments with 458 cwt/acre U.S. No. 1, and the -30 kPa treatments with 468 cwt/acre, produced more U.S. No. 1 than the -45 and -60 kPa treatments, 398 and 339 cwt/acre, respectively. Marketable yield for processing, which included the U.S. No. 1 and U.S. No. 2 grades, averaged 548 cwt/acre overall, with the -45 and -60 kPa treatments producing progressively less marketable yield.

2001 Tuber Quality

Stem end fry color was the only tuber quality variable affected by irrigation levels and tape placement (Table 2). A high percentage (7 percent) of sugar ends resulted from the use of one tape for two rows and irrigation at -45 kPa. Average tuber fry color was not affected by tape placement or soil water potential irrigation level. Tuber specific gravity was not affected by irrigation level and tape placement.

2001 Water Use

The automated irrigation system applied substantially more water than Et_c of 25.7 inches to the -15 kPa treatment with one tape per two rows, which received 32.9 inches of water (Fig. 2). The -30 kPa treatment with one tape per two rows received 27.7 inches, slightly more than Et_c. One tape per row at -15 kPa resulted in 18.0 inches of water applied. The -30 kPa treatment with one tape per row applied 18.0 inches, the -45 kPa treatment with one tape per two rows applied 22.9 inches, and the -45 kPa with one tape per row applied 15.5 inches. The -60 kPa treatment with one tape per two rows applied 21.3 inches, and the -60 kPa with one tape per row applied 11.0 inches.

The automated, sensor-driven irrigation was a feedback control system, and soil water potential oscillated around the average treatment criteria (Fig. 3). This oscillation was more pronounced in the drier treatments, which had a pattern of irrigating four times a day for 3 or 4 days then not irrigating for 3 days. The two -15 kPa treatments irrigated every day, but not always all four times every day. The treatments with one tape per row received less water for a given soil water potential criterion because the sensors

were closer to the tape, which increased the efficiency in wetting the GMS and reduced lag time in the feedback oscillation of irrigation frequency.
During the 2001 season, average potato yields were 402 cwt/acre in Malheur County. Yields in the current trial were higher, possibly in part because the field had not grown a potato crop in 10 years. Many growers have a shorter rotation between potato crops, which usually leads to increased pathogens in the soil. Typically, 43.2 inches of water are applied using furrow irrigation, and 36 inches are applied using sprinkler irrigation. From the county yield and water use figures, sprinkler and furrow irrigation result in 1,116 and 931 lb of potatoes for each acre-inch/acre of water applied. Using drip irrigation with a tape for every row and irrigating at -30 kPa, yield was 3,217 lb/acre for each acre-inch/acre of applied water, with adequate tuber grade and quality. The -45 and -60 kPa treatments with one tape per row had water use efficiency of 2,707 and 2,854 lb/acre for each acre-inch/acre of applied water, but tuber quality was adversely affected at these drier irrigation criteria.

Combined 2000 and 2001

When the data for both years were analyzed together, the tape placement factor (one tape per row or one tape for two rows) had a significant effect on every variable except total marketable yield and tuber bud-end fry color for which interaction effects with tape number were significant (Table 3). Irrigation with one tape for two rows at -15 or -30 kPa produced more total yield than drier treatments. Marketable yield, which includes tubers with defects that cause them to be graded U.S. No. 2, was highest with one drip tape for two rows of potatoes, and the -15 and -30 kPa irrigation levels. One tape for two rows produced more tubers over 12 oz, which can be undesirable for processing if the tubers are too large to fit through the French fry cutting machinery. One tape per row produced more tubers in the 6- to 12-oz category, but also produced more tubers under 4 oz, which could cause volunteer potato problems as they may remain in the soil after harvest. With one tape per row, specific gravity was higher, stem-end fry color was lighter, and there were fewer sugar ends. With one tape per two rows, the highest incidence of sugar ends, 8 percent, was at the -15 kPa irrigation level. If the contract allowed a tolerance for sugar ends, one drip tape for two rows could be more economical. There were more cull potatoes with the -15 kPa irrigation with either one tape per row or one tape for two rows.

The irrigation criterion considered alone only influenced the total U.S. No. 1 and over-12-oz size categories, producing more U.S. No. 1 tubers and fewer oversized tubers over 12 oz, with a tape on each row. Tuber defects that graded U.S. No. 2 were highest with the -15 and -30 kPa irrigation levels.

Tape placement and irrigation criterion interacted to influence total yield, total marketable potatoes, and U.S. No. 2 yield, due to higher yield with one tape per two rows but more U.S. No. 2 tubers. The year variable showed a difference in stem-end fry color and sugar ends, with more in 2000. The tape-by-year interaction was significant for percent U.S. No. 1, total yield, with more U.S. No. 1 tubers at the wetter irrigation criteria in 2001, and also significant effects on 6- to 12-oz, under 4 oz, percent U.S. No. 2, culls, and bud-end fry color. The irrigation criteria by year interaction was significant only for culls. The three-way interaction of tape, kPa, and year was significant for percent U.S. No. 1, marketable, total U.S. No. 1, U.S. No. 2, stem-end fry color, and sugar ends.

Yield Response to Applied Water

The relationship between the yield of marketable tubers for processing and water applied was best described by second order polynomial equations, where y = marketable yield, and x = inches of water applied (Fig. 4). The equations describe diminishing returns for water application and little return for water application in excess of Et_c. There was a marketable yield penalty for irrigation treatments that applied less than Et_c, regardless of the production potential of the system. In 2000, when total yields were less, the equation describes a slight penalty in marketable yield for irrigation in excess of 27.6 inches while Et_c was 24.5 inches. In 2001 the model described maximum marketable yield at 31.0 inches while Et_c was 25.7 inches. The linear regression models (not shown) responded with an 8.9 cwt/acre increase in marketable yield for each additional inch of water applied in 2001, and a 7.2 cwt/acre increase for each additional inch of water in 2000.

Future Opportunities with Drip Irrigation

The drier treatments in this study were based on soil water potential that would be in the acceptable range of dryness for furrow or sprinkler irrigated potatoes. With this soil moisture sensor-driven automated drip irrigation system the drier treatments often had several days between irrigations, as shown by the flat regions of the lines in the graphs of applied water (Fig. 1 and 2). If the objective were to grow a potato crop with a limited water supply, the tuber grade and quality might be harmed less with a daily irrigation with a fraction of Et_c.

Other research has shown that application of irrigation that closely matches the water needs of the crop results in better nitrogen use efficiency and reduced leaching potential. Less N fertilizer was required in the current trials than is routinely used by growers.

Drip irrigation might be used to deliver systemic fungicides or insecticides in small doses directly to the root system of the crop, possibly reducing production costs and chemical use. Hypothetically, these smaller doses might be able to substitute for high rates of soil fumigants used to prepare the soil for a potato crop. A systemic fungicide might replace aerial spraying on a scheduled basis to protect the foliage from late blight. Systemic fungicide could also potentially improve yields by preventing early vine death, thus prolonging the growing season.

Table 1. 'Umatilla Russet' 2000 yield, grade, and processing quality when grown with automated drip irrigation using either one tape for two rows or a tape for every row, at four levels of soil water potential. Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

				Yield by grade									Fry color			
Number of drip tapes		U.S. No. 1	Total yield	Total marketable	Total U.S. No. 1	Over 12 oz	6 to 12 oz	4 to 6 oz	Under 4 oz	U.S. No. 2	Cull	Specific gravity	Stem end	Bud end	Average	Sugar ends
	kPa	%	cwt/acre									$g\ cm^{-3}$	% Reflectance			%
one per two rows	-15	66	506	445	337	168	149	20	40	109	21	1.0882	34	42	38	11.0
	-30	69	455	397	318	144	146	28	51	79	8	1.0928	33	42	37	12.0
	-45	67	465	412	314	135	151	27	43	99	11	1.0872	35	43	39	4.5
	-60	66	439	383	290	101	155	34	51	93	5	1.0871	34	43	38	7.5
	Mean	67	466	409	314	137	150	27	46	95	11	1.0888	34	42	38	8.8
one per row	-15	74	507	413	374	101	225	49	73	39	21	1.0933	39	45	42	3.0
	-30	74	516	429	382	78	244	60	79	47	8	1.0957	37	44	40	3.0
	-45	67	448	347	301	46	188	67	92	46	9	1.0903	33	42	38	11.5
	-60	65	413	317	269	47	158	64	87	48	9	1.0917	36	43	39	8.5
	Mean	70	471	376	331	68	204	60	83	45	12	1.0928	36	44	40	6.5
Average	-15	70	506	429	355	134	187	34	56	74	21	1.0907	36	44	40	7.0
	-30	72	486	413	350	111	195	44	65	63	8	1.0943	35	43	39	7.5
	-45	67	457	380	307	90	170	47	67	72	10	1.0888	34	43	38	8.0
	-60	65	426	350	279	74	156	49	69	71	7	1.0894	35	43	39	8.0
Overall	Mean	69	469	393	323	102	177	44	64	70	12	1.0908	35	43	39	7.6
LSD(0.05)	Tapes	NS	NS	37	NS	23	19	8	10	18	NS	0.0032	2	1	2	NS
	kPa	6	46	52	47	32	27	12	NS	NS	10	0.0045	NS	NS	NS	NS
	Tapes x kPa	NS	65	73	66	NS	39	NS	NS	NS	NS	NS	4	NS	3	NS

Table 2. 'Umatilla Russet' 2001 yield, grade, and processing quality when grown with automated drip irrigation using either one tape for two rows or a tape for every row, at four levels of soil water potential. Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

				Yield by grade									Fry color			
Number of drip tapes		U.S. No. 1	Total yield	Total marketable	Total U.S. No. 1	Over 12 oz	6 to 12 oz	4 to 6 oz	Under 4 oz	U.S. No. 2	Cull	Specific gravity	Stem end	Bud end	Average	Sugar ends
	kPa	%	cwt/acre									g cm^{-3}	% Reflectance			%
one per two rows	-15	69	651	619	451	285	158	8	11	167	17	1.0884	39	48	43	4.0
	-30	70	658	623	460	274	175	11	11	163	19	1.0906	40	46	43	2.0
	-45	60	620	580	370	178	182	11	14	210	20	1.0892	39	46	43	7.4
	-60	49	608	566	297	131	158	8	14	269	28	1.0886	41	47	44	3.0
	Mean	62	634	597	394	217	168	9	12	202	21	1.0892	40	47	43	4.1
one per row	kPa															
	-15	82	563	535	464	165	265	34	18	71	10	1.0915	41	47	44	3.0
	-30	82	579	547	477	140	304	34	18	70	10	1.0920	41	47	44	3.0
	-45	83	515	481	425	141	241	42	20	56	12	1.0922	43	46	45	0.0
	-60	82	467	431	381	71	274	37	25	50	7	1.0900	41	46	44	0.0
	Mean	82	531	499	437	129	271	37	20	62	10	1.0914	42	46	44	1.5
Average	kPa															
	-15	76	607	577	458	225	212	21	15	119	13	1.0900	40	47	44	3.5
	-30	76	618	585	468	207	239	22	14	117	14	1.0913	41	46	44	2.5
	-45	71	567	531	398	160	212	27	17	133	16	1.0907	41	46	44	3.7
	-60	65	537	498	339	101	216	22	19	159	18	1.0893	41	46	44	1.5
Overall	Mean	72	582	548	416	173	220	23	16	132	15	1.0903	41	47	44	2.8
LSD(0.05)	Tapes	4	12	13	35	53	61	8	4	24	7	NS	2	NS	NS	NS
	kPa	NS	NS	18	49	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Tapes x kPa	8	NS	NS	NS	NS	NS	NS	NS	48	NS	NS	NS	NS	NS	5.4

Table 3. 'Umatilla Russet' average of 2000 and 2001 yield, grade, and processing quality when grown with automated drip irrigation using either one tape for two rows or a tape for every row, at four levels of soil water potential. Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

Number of drip tapes		U.S. No. 1	Total yield	Yield by grade: Total marketable	Total U.S. No. 1	Over 12 oz	6 to 12 oz	4 to 6 oz	Under 4 oz	U.S. No. 2	Cull	Specific gravity	Fry color: Stem end	Bud end	Average	Sugar ends
	kPa	%	cwt/acre									g cm^{-3}	% Reflectance			%
one per two rows	-15	68	578	532	355	226	154	14	26	138	21	1.0883	37	45	41	7.5
	-30	70	557	510	350	209	160	20	31	121	8	1.0917	36	44	40	7.0
	-45	64	542	496	307	157	167	19	28	154	10	1.0882	37	45	41	6.0
	-60	57	524	474	279	116	156	21	32	181	7	1.0878	37	45	41	5.3
	Mean	65	550	503	354	177	159	18	29	149	18	1.0890	37	45	41	6.4
one per row	-15	78	535	474	458	133	245	41	45	56	15	1.0924	40	46	43	3.0
	-30	78	547	488	469	109	274	47	48	59	8	1.0939	39	45	42	3.0
	-45	75	481	414	398	93	215	55	56	51	10	1.0912	38	44	41	5.8
	-60	73	440	375	339	59	216	50	56	49	7	1.0909	39	45	42	4.3
	Mean	76	501	438	384	98	237	48	51	53	12	1.0921	39	45	42	4.0
Average	-15	73	557	503	407	180	199	28	36	97	18	1.0904	38	46	42	5.3
	-30	74	552	499	409	159	217	33	40	90	14	1.0928	38	45	41	5.0
	-45	69	512	455	353	125	191	37	42	103	15	1.0897	38	44	41	5.9
	-60	65	482	424	309	87	186	36	44	115	13	1.0894	38	45	41	4.8
Overall	Mean	70	526	470	369	138	198	33	40	101	15	1.0906	38	45	41	5.2
LSD(0.05)	Tapes	2	12	NS	16	19	20	4	4	10	4	0.0019	1	NS	1	2.1
	kPa	NS	NS	NS	23	27	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Tapes x kPa	NS	24	28	NS	NS	NS	NS	NS	20	NS	NS	NS	NS	NS	NS
	Year	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	2	NS	NS	2.9
	Tape x Year	3	17	NS	NS	NS	28	NS	6	14	7	NS	NS	1	NS	NS
	kPa x Year	NS	NS	NS	NS	NS	NS	NS	NS	NS	7	NS	NS	NS	NS	NS
	Tape x kPa x Year	6	NS	20	32	NS	NS	NS	NS	28	NS	NS	3	NS	NS	5.9

Figure 1. Cumulative potato AgriMet evapotranspiration (ET_c) in 2000 and cumulative water applied (plus rainfall) by eight different drip irrigation treatments. Irrigation was automated at soil water potential of -15, -30, -45, or -60 kPa with either one tape (1t, between two potato rows), or two tapes (2t, one tape per row). Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

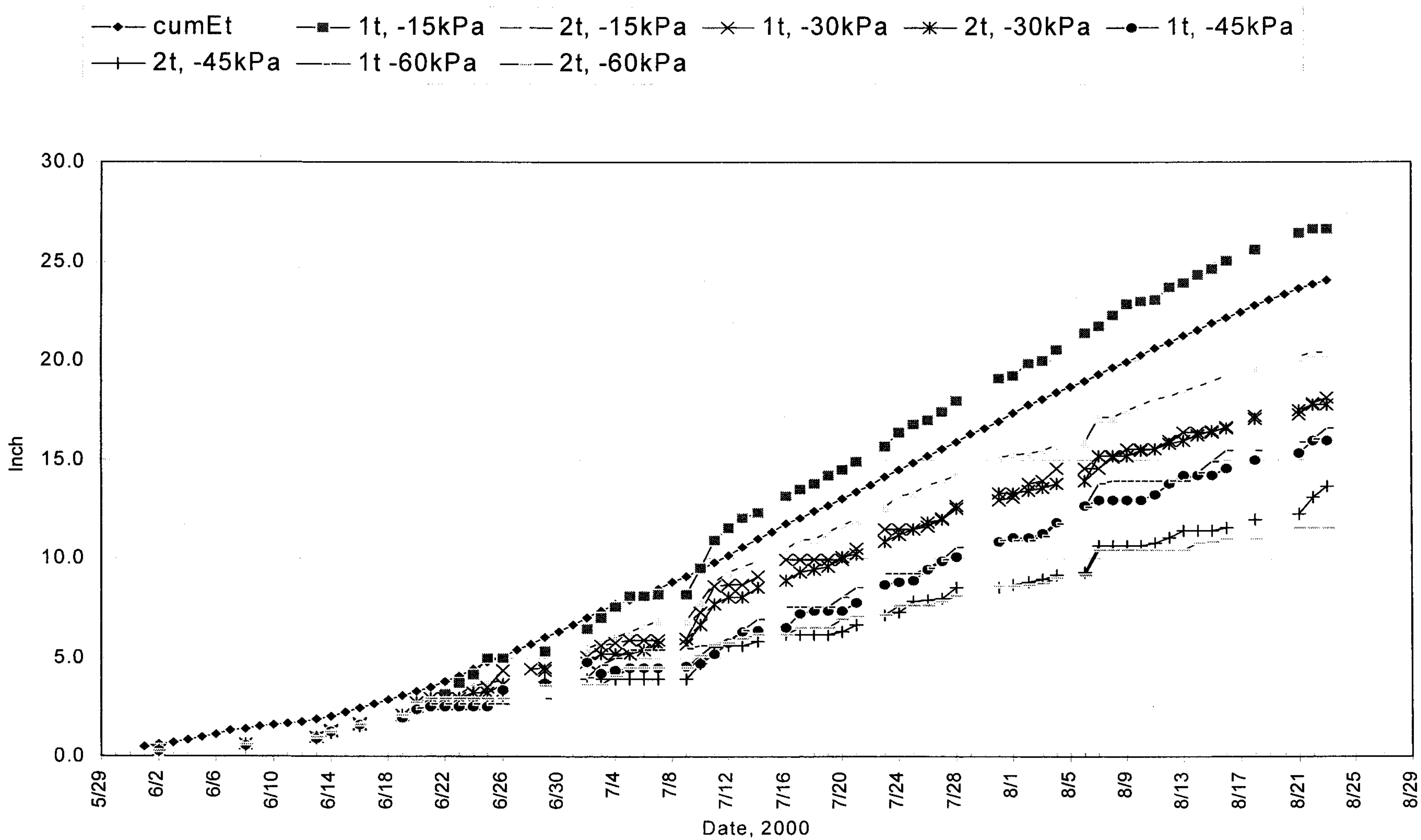


Figure 2. Cumulative potato AgriMet evapotranspiration (ET_c) in 2001 and cumulative water applied (plus rainfall) by eight different drip irrigation treatments. Irrigation was automated at soil water potential of -15, -30, -45, or -60 kPa with either one tape (1t, between two potato rows), or two tapes (2t, one tape per row). Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

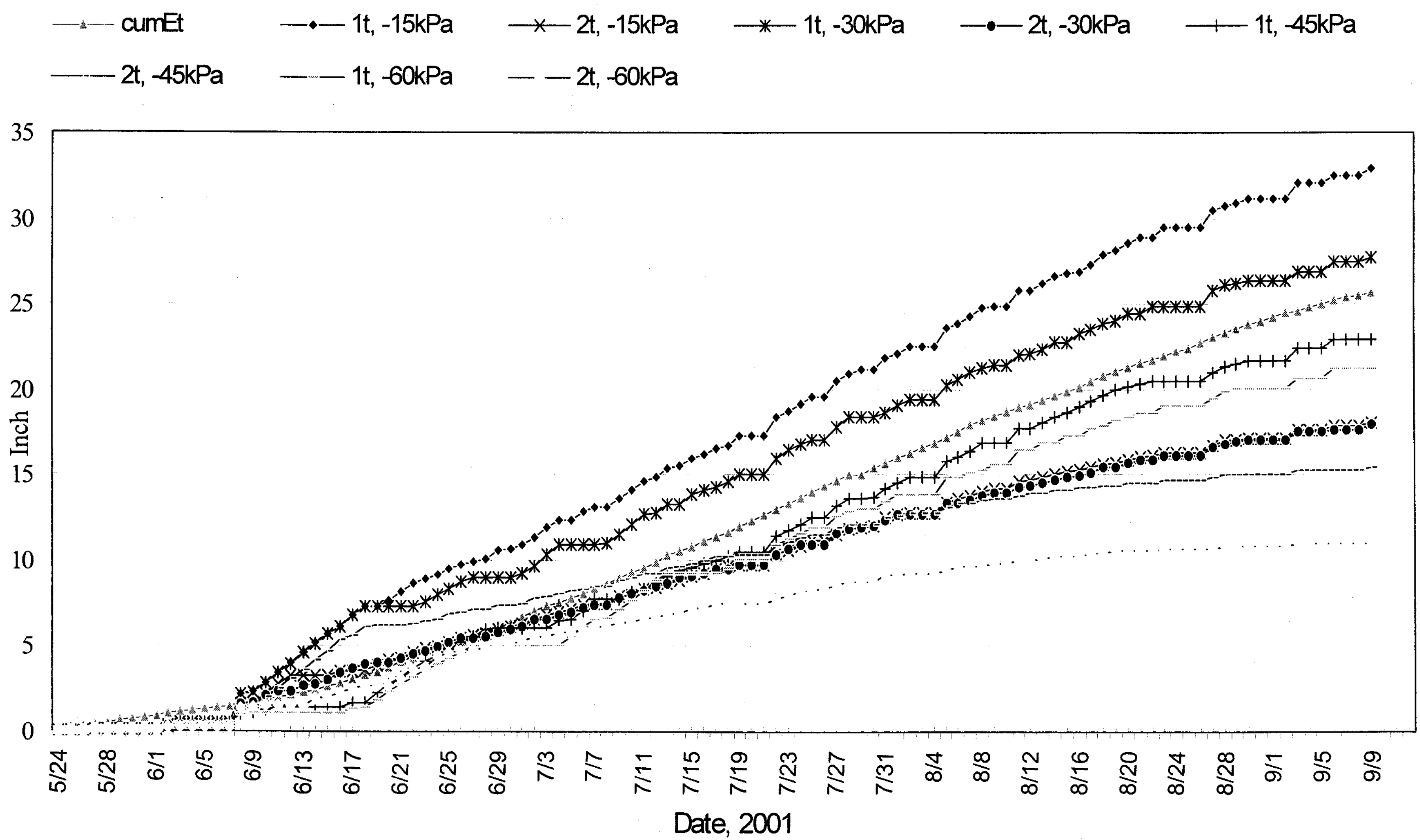


Figure 3. Soil water potential in 2001 of automated, sensor-driven drip irrigation treatments at four levels of soil water potential and with either one drip tape per potato row, or one drip tape between two potato rows. Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.

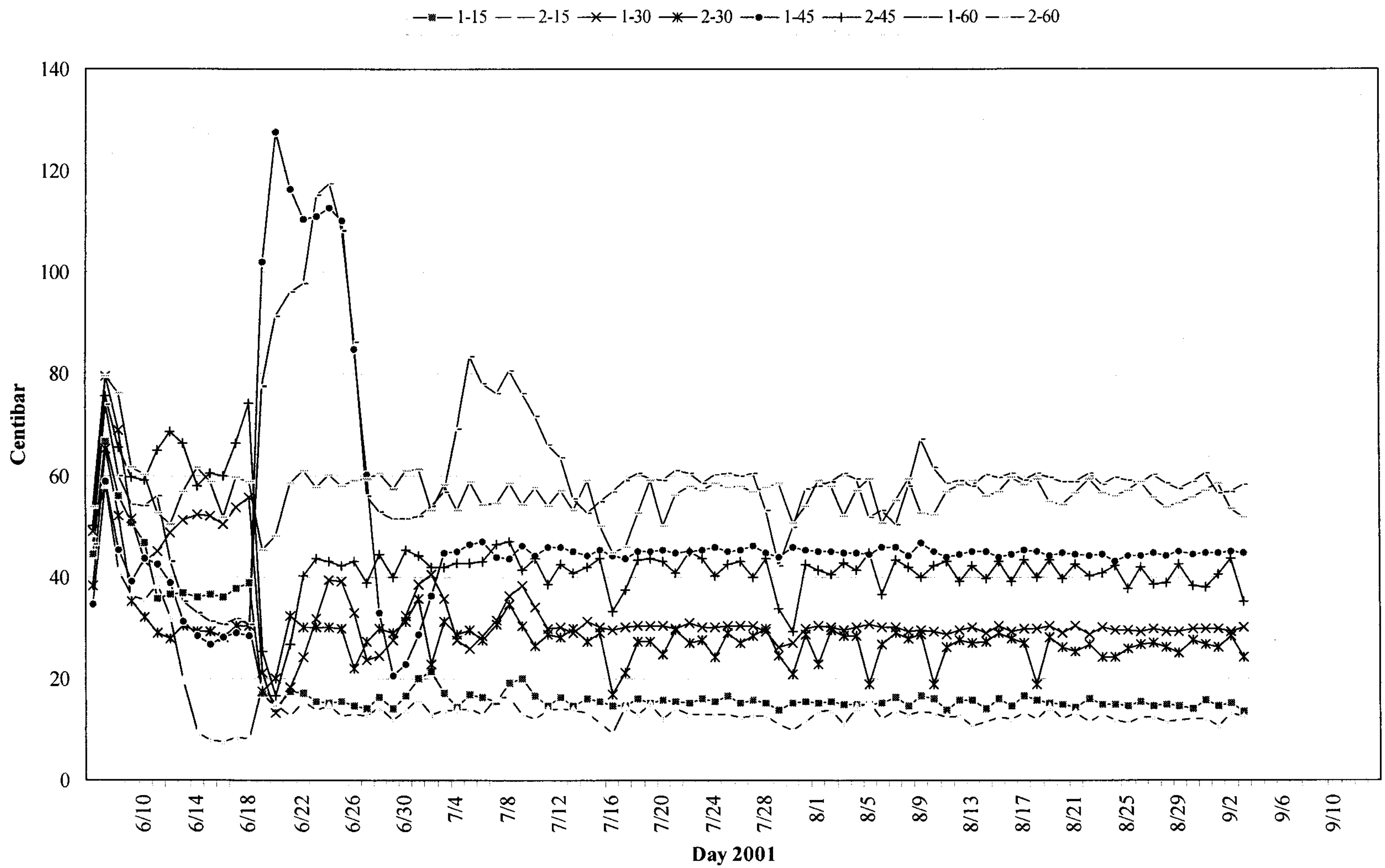
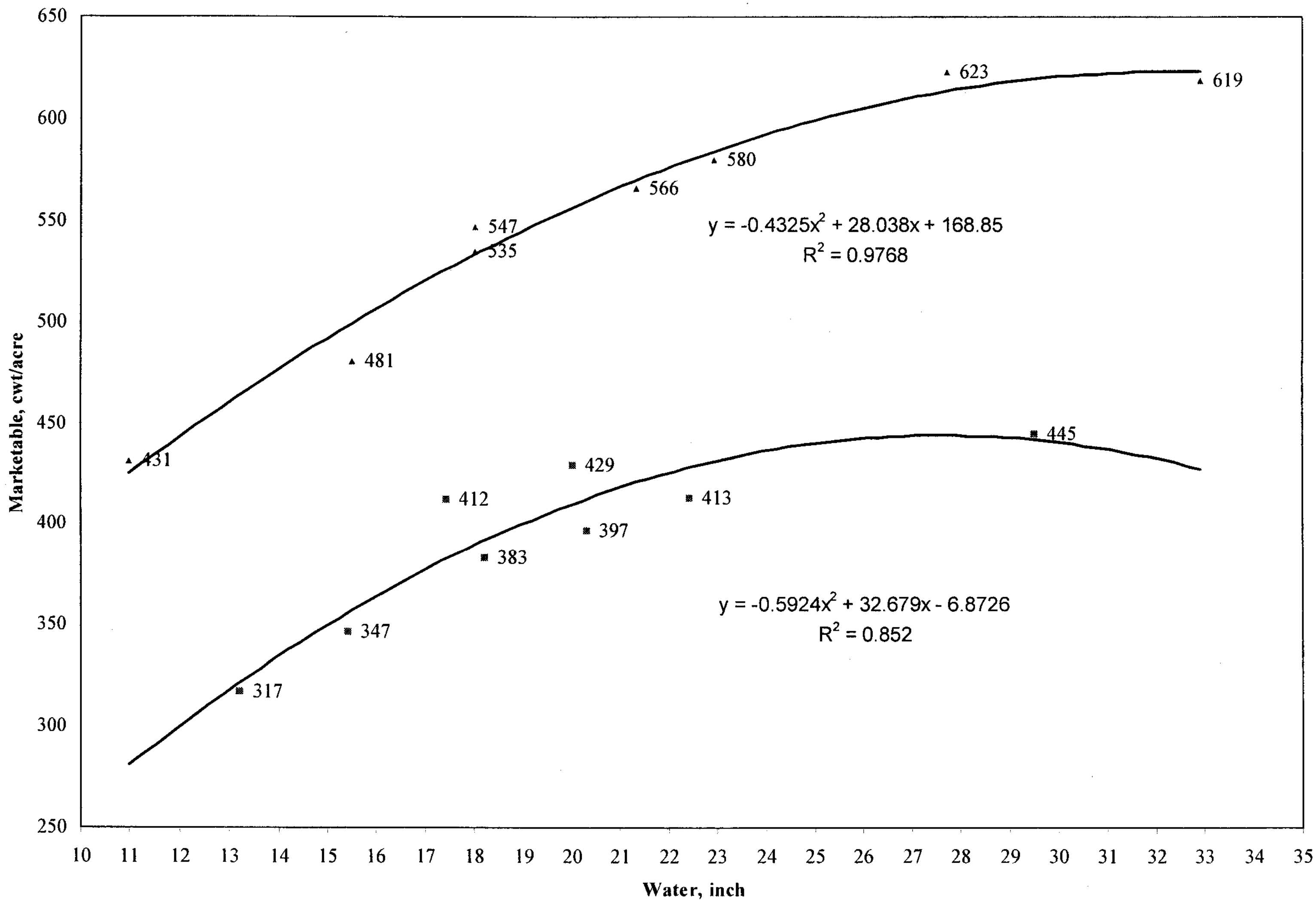


Figure 4. The relationship of water applied with automated drip irrigation treatments (plus rainfall) to marketable tuber yield for 2000 (squares) and 2001 (triangles). Malheur Experiment Station, Oregon State University, Ontario, OR, 2002.



DRIP-IRRIGATED RED AND RUSSET POTATO VARIETIES HARVESTED EARLY OR LATE

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Ontario, OR, 2001

Introduction

This was the third year of testing the adaptation of russet potato varieties to drip irrigation, and the second year of testing red-skinned varieties. The early- and late-harvest russet trials compared the russeted varieties 'Alturas', 'Wallowa Russet', 'Gem Russet', 'Klamath Russet', 'Umatilla Russet', and 'Russet Burbank', to 'Shepody', and two numbered lines, 'A90586-11' and 'AO92023-3'. 'Shepody', a white-skinned variety, was included because it is grown for processing, 'A90586-11' has shown resistance to late blight, and 'AO92023-3' has performed well at this location in previous trials. The early- and late-harvest red-skinned variety trials compared 'Dark Red Norland', 'Mazama', 'Red LaSoda', 'Sangre 14', and 'Winema', the yellow-fleshed variety 'Yukon Gold', and two red-skinned selections, 'CO89097-2', and 'NDO4300-1'.

Water quality and scarcity issues may increase interest in drip irrigation for russet potato production, both for processing and fresh market. The high prices sometimes paid for red-skinned and specialty potato varieties for fresh market may encourage some growers to try to produce them using drip irrigation. The objectives of this study were to evaluate the performance of new varieties and advanced numbered lines in comparison to standard potato varieties under drip irrigation, and to explore the applicability of drip irrigation to potato production in Malheur County.

Materials and Methods

The 2001 drip-irrigated early- and late-harvest red and russet variety trials were grown on a field of Owyhee silt loam where winter wheat was the previous crop. The wheat stubble was flailed, the field was furrow irrigated, then disked, and 100 lb P/acre and 20 lb N/acre were broadcast. In the fall, the field was ripped with Telone II injected at 22 gal/acre, and the field was bedded on 36-inch row spacing. A soil test taken on April 17, 2001 showed available nitrate plus ammonia totaled 67.5 lb N/acre in the top 2 ft of soil. The top ft of soil had 20 ppm extractable P, 272 ppm K, 1 percent organic matter, and pH 7.8.

Seed of all varieties was hand cut into 2-oz seedpieces and treated with Tops-MZ-Gaucho dust. The early-harvest red and russet trials were planted April 12, and the late-harvest red and russet trials were planted April 19 . Each trial had five replicates, with varieties as treatments, in a randomized complete block design. Potato seed was planted using a Parma two-row cup planter (Parma Corp., Parma, ID) with the center furrowing shovel removed. Seedpiece spacing was 9 inches in the row, with rows 36 inches apart. Plots were two rows wide by 22.5 ft (30 seedpieces) long, with five red seedpieces separating the plots of russeted varieties and five white seedpieces separating the plots of red varieties.

Prowl at 1 lb ai/acre plus Dual at 2 lb ai/acre, in 30 gal/acre spray mix, was applied on May 1, 2001 and incorporated with a spike-tooth bed harrow. The bed harrow had a toolbar on the back carrying wide shovels to lift soil out of the furrows. A 16-ft length of 5/8-inch chain dragged in a "vee" from the shovel shanks pulled soil into the center of the bed. On the second pass with the bed harrow, in the opposite direction from the first pass, drip tube was injected 2-3 inches deep in the center of the level bed between the two potato rows. The drip tube was 1000 Path (Nelson Irrigation, Walla Walla, WA) that was 8 mil thick, 5/8 inches diameter, and had 12-inch emitter spacing, with a flow rate of 0.22 gal/min/100 ft at 10 psi. Matrix herbicide was applied at 1.2 oz/acre on May 7.

The potatoes in both sets of trials were irrigated with one drip tube between two rows of potatoes on a raised bed. Irrigations were automated to maintain the soil water potential at -30 centibar in the root zone measured with Watermark sensors (Irrometer Co. Inc., Riverside, CA). The sensors were positioned between potato plants in the row with the center of the sensor 8 inches deep. All the nitrogen fertilizer was injected through the drip tape. A 120-gal tank was used to hold a solution of 150 lb calcium nitrate dissolved in 111 gal of water. The solution was metered into the irrigation water using a model A30-2.5 Dosmatic metering pump (Dosmatic USA International, Inc., Carrolltown, TX) at a rate of 1 gal of fertilizer solution to 500 gal of irrigation water. Fertilizer was injected to supply 50 ppm NO_3 in the drip irrigation water, beginning with the first irrigation on May 26.

The first petiole test on June 11 showed deficiencies, so on June 17 and 18, 11 lb N/acre, 8 lb S/acre, 0.17 lb Cu/A, and 0.21 lb Mn/acre were injected. From June 18 to July 16, calcium nitrate fertilizer solution was injected to maintain 50 ppm NO_3 in the drip system. On July 17 to 18, 10 lb S/acre, 5 lb Mg/acre, 0.25 lb Zn/acre, and 0.25 lb Mn/acre were injected to correct deficiencies shown in the third petiole test, taken on July 12. From July 18 to July 31, calcium nitrate solution was again injected at 50 ppm NO_3. The total applied N fertilizer was 224 lb N/acre applied to the early-harvest trials, and 191 lb N/acre applied to the late-harvest trials. Irrigations were continued without fertilizer injection until August 12 for the early-harvest trials, for a total of 17 acre-inch/acre of irrigation water, and September 10 for the late-harvest trials, for a total of 20 acre-inch/acre of irrigation water.

Fungicide applications to prevent late blight infection consisted of an aerial application of Ridomil Gold and Bravo at 2 lb/acre on June 14 and Dithane at 4 pint/acre on June 22. Powdered sulfur was applied at 30 lb/acre by aerial application on July 14, and again on July 28, to control powdery mildew.

Early-harvest Trials

Vines were flailed in the early-harvest trials on August 13, 90 days after full emergence. Early-harvest red and russet potatoes were lifted August 24 with a two-row digger that laid the tubers back onto the soil in each row. Potatoes were visually evaluated for desirable traits, such as smooth, uniform shape and size, oblong to long, well russetted tubers, with shallow eyes. 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, drab color on red varieties, pigmented eyes, and other defects. The drip tape was dug along with the potatoes. After the potatoes had been picked up, the drip tape was gathered and tied in bundles for disposal. Potatoes were placed into burlap sacks and hauled to a barn where they were kept under tarps until grading on August 27 and 28.

Red varieties should have a high yield of uniformly shaped, small, smooth, brightly colored tubers. The red varieties were graded into categories that reflected their usual culinary, and therefore fresh market, uses. The total yield of tubers under 10 oz was considered the marketable yield. The under 2 oz, and 2- to 5-oz size categories can command premium prices, while tubers over 10 oz are frequently unmarketable.

A 20-tuber sample from each plot of the russet varieties was placed into refrigerated storage for processing quality tests. The storage was kept near 100 percent relative humidity and the temperature was gradually reduced to 45°F. Tubers were removed from storage November 29 and 30 and evaluated for tuber quality traits. Specific gravity was measured using the weight-in-air, weight-in-water method, and 20 tubers per plot were cut lengthwise and examined for internal defects. Center slices from 20 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 fried 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.

Late-harvest Trials

Vines were flailed off the late-harvest red and russet trials on September 19, 122 days after full emergence. The potatoes were lifted on September 28 and visually evaluated as described above. Tubers were graded October 10 and a 20-tuber sample from each plot of the russet varieties was placed into storage. Tubers were removed from storage December 3 and 4 and evaluated for tuber quality traits. Specific gravity, internal defects, and percent light reflectance were measured as described above.

Results and Discussion

There were unusually large fluctuations in temperature during April and May of 2001. Potatoes planted on April 12 began to emerge a few days earlier than potatoes planted on April 20, but emerged less uniformly, with some of the red varieties emerging earliest. Some of the early planted russet varieties were slower to emerge than the later planted reds. The potatoes in the early-harvest trials had fully emerged by May 15, and the potatoes in the late harvest trials had fully emerged by May 20. Dry weather prevented late blight from developing in 2001. Precipitation for April through August was 2.03 inches.

The total pan evaporation in 2001 measured by the U.S. Weather Bureau Class A pan at Malheur Experiment Station in April through September was 58.3 inches, compared to the historical average of 52 inches. Cumulative potato evapotranspiration (Et_c) measured at the Malheur Experiment Station US Bureau of Reclamation (USBR) Agrimet weather station was 21.5 inches for the early-harvest potatoes, and 26.8 inches for the late harvest. The USBR Et_c is based on water use of sprinkler irrigated 'Russet Burbank'. The automated drip irrigation system applied 16.9 inches of water to the early-harvest trials, so including rain, the early-harvest trials received only 88 percent of Et_c. The automated drip irrigation system applied 19.8 inches of water to the late-harvest trials, so including rain, the late-harvest trials received only 81 percent of Et_c.

Red Early- and Late-harvest

Harvested early, the red-skinned varieties (including 'Yukon Gold') average total yield was 569 cwt/acre (Table 1). Among the highest total yields were 'Mazama' at 598 cwt/acre, 'Red LaSoda' and 'Dark Red Norland' at 594 cwt/acre, 'CO89097-2' at 592 cwt/acre, 'NDO4300-1' at 590 cwt/acre, and 'Winema' at 582 cwt/acre. The yellow variety 'Yukon Gold' produced 539 cwt/acre, and 'Sangre 14', at 462 cwt/acre, produced the lowest total yield.

Harvested late, the average total yield was 603 cwt/acre, with 'Red LaSoda' producing the highest total yield at 695 cwt/acre. The new Oregon release 'Mazama' produced the highest yield of U.S. No. 1 tubers under 10 oz, with 324 cwt/acre.

In each harvest 'Mazama' and 'NDO4300-1' tubers were smooth and uniformly shaped, with bright red skin. 'Winema' tubers were slightly irregular in shape and generally too large. 'Red LaSoda', 'Sangre 14', and 'Dark Red Norland' tubers were rough and very irregular in shape, with a dull, unattractive pink to red skin color. 'CO89097-2' tubers were uniform, with dark red color, but some tubers were too large and had growth cracks. 'Yukon Gold' tubers were irregularly shaped, with scab, growth cracks, and folded bud ends.

Russet Early- and Late-harvest

In the early-harvest russet varieties, the average total yield was 559 cwt, with high yields by 'AO92023-3' at 605 cwt/acre, 'Klamath Russet' at 600 cwt/acre, 'Russet Burbank' at 571 cwt/acre, 'Wallowa Russet' at 570 cwt/acre, and 'Umatilla Russet' at 569 cwt/acre total yield (Table 2). The percentage U.S. No. 1 tubers produced by 'Gem Russet' was 84 percent followed by 'AO92023-3' with 78 percent, 'Alturas Russet' with 72 percent, 'Klamath Russet' with 68 percent, 'Umatilla Russet' with 67 percent, and 'Wallowa Russet' with 66 percent U.S. No. 1. 'Russet Burbank' produced only 36 percent U.S. No. 1.

Marketable yield includes U.S. No. 1 grade tubers over 4 oz and U.S. No. 2 grade tubers. In marketable yield for the early-harvest russets, 'AO92023-3' at 550 cwt/acre, and 'Klamath Russet' at 544 cwt/acre were among the highest. The early-harvest russets with the lightest stem-end fry color were 'Alturas Russet' with 48.6 percent light reflectance, and 'Gem Russet' with 48.5 percent light reflectance.

In the late-harvest russet trial, the overall average total yield was 580 cwt/acre, ranging from 632 cwt/acre for 'Russet Burbank', to 514 cwt/acre for 'Shepody'. 'Wallowa Russet' at 553 cwt/acre had among the highest marketable yield in the late-harvest russet trial along with 'Alturas Russet', 'A90586-11', and 'Klamath Russet'. In the late-harvest russet trial 'Alturas Russet', and 'Gem Russet' were among the lines with the lightest stem-end fry color. 'Klamath Russet' is considered a fresh market variety, and its specific gravity was too low for processing in this trial.

The appearance of the tubers at both harvests showed striking differences. 'Gem Russet' tubers were attractive and uniformly shaped, but rather small and too round. 'AO92023-3' tubers were very nicely sized and shaped, but a little irregular with some growth cracks and knobs. 'Umatilla Russet' tubers were slightly irregular, with some knobs and curved tubers. 'Alturas' tubers were too round, with growth cracks and some pointed ends. 'AO90586-11' tubers were irregularly shaped, curved, and with some heart-shaped double tubers and scab. 'Wallowa' tubers were pointed, irregular, and curved. 'Klamath Russet' tubers were irregularly shaped, pointed, and had deep eyes and some folded bud ends. 'Russet Burbank' tubers were severely irregular, with knobs, pointed ends, curved tubers, and growth cracks. 'Shepody' tubers were very irregular in shape and size, with growth cracks, knobs, and scab.

Difference between Early and Late Harvests

These trials compared two matched sets of plots, grown in the same field but planted and harvested at different times. Any differences among the averages for varieties planted and harvested early when compared to the same variety planted and harvested late cannot be assigned a probability because the sources of variability cannot be evaluated. Some of the differences were large enough to raise questions that could be tested in future research.

In comparing the early- and late-harvest yields of the red-skinned varieties, 'Red LaSoda' increased 100 cwt/acre at the end of the season, mostly by bulking tubers larger than 10 oz. 'Mazama', on the other hand, had the least increase in tubers over 10 oz, suggesting there may be a genetic mechanism limiting tuber size in 'Mazama', a valuable trait in a red potato.

The high proportion of cull tubers in the early-harvest red trial, compared to the late harvest, may be because cool soil temperature at the early planting date slowed emergence and allowed early infection of stems, roots, and stolons with soil pathogens such as *Rhizoctonia* and *Verticillium*. Because the trials were harvested separately, they were on different irrigation zones in the drip system, and irrigation differences may have led to excessive culls in the early-harvest red trial.

'Alturas Russet' had a large increase in yield of marketable tubers between early and late harvests, 73 cwt/acre. Late season productivity suggests healthier vines or roots in the later part of tuber bulking. Late season plant health may be a reflection of resistance to verticillium wilt or another pathogen that contributes to early vine death. All of the russets except 'Gem Russet' had increased specific gravity in the late-harvest trial. Harvested late, 'AO92023-3' was less productive in all tuber grades, possibly due to PVY infection in the seed, which was not discovered until after these trials had been conducted.

The yields of these drip-irrigated trials were greater in 2001 than in previous years (Shock, et al. 1999, 2000). In 2001, one difference was that the drip-irrigation system was used to inject nutrients that the petiole tests showed were becoming deficient in June and July. Other changes in procedure in 2001 were the use of a seed treatment dust with Gaucho insecticide, instead of Thimet granules in the seed furrow at planting, an aerial application on June 14 of a combination of metalaxyl and chlorothalonyl along with chelated micronutrient metals copper and manganese, and application of Matrix herbicide. Another difference was planting the trials in a field that had not grown a potato crop for 10 years. The 1999 trials were in a field that had grown potatoes in 1987, 1991, and 1995, and the 2000 trials were in a field that had grown potatoes in 1988, 1992, and 1996. The usual 4-year rotation at Malheur Experiment Station, with 3 years out of potatoes, is similar to the rotation used by some growers. Longer rotations out of potatoes can result in lower disease pressure and higher yields.

The automated drip-irrigation system applied 12.9 inches of water to the early-harvest trials in 2000, and 16.9 inches of water in 2001. On the late-harvest trials, the automated drip-irrigation system applied 20.3 inches of water to the trials in 2000, and 19.8 inches of water in 2001. Those differences in irrigation may also have influenced the differences seen in potato variety responses to early- and late-harvest in the 2 years.

References

Shock, C.C., E.P. Eldredge, and L.D. Saunders. 1999. Early and late harvest drip-irrigated red and russet varieties. Oregon State University Agricultural Experiment Station Special Report 1015:127-133.

Shock, C.C., E.P. Eldredge, and L.D. Saunders. 2000. Early and late harvest potato variety response to drip irrigation. Oregon State University Agricultural Experiment Station Special Report 1029:134-144.

Table 1. Red potato varieties harvested after 90 or 122 days of vine growth: yield, grade, and difference between the harvest dates. Malheur Experiment Station, Oregon State University, Ontario, OR 2001.

		U.S. No. 1							U.S. No. 2			
Variety	Total yield	Percent No. 1	Total No. 1	<10 oz	<2 oz	2 to 5 oz	5 to 10 oz	>10 oz	<10 oz	>10 oz	Cull	Rot
	cwt/acre	%	cwt/acre									
Early harvest												
CO89097-2	592	76.2	452	174	8	21	145	278	19	27	85	9
D. R. Norland	594	56.9	337	162	9	36	116	176	11	32	209	4
Mazama	598	82.3	492	296	6	47	243	196	9	41	54	3
NDO4300-1	590	72.7	428	230	8	47	176	198	13	45	99	5
Red LaSoda	595	43.5	258	138	20	43	75	121	10	37	287	2
Sangre 14	462	60.1	275	191	28	63	100	84	15	30	142	
Winema	582	54.6	317	115	6	16	93	203	13	49	196	7
Yukon Gold	539	70.4	377	185	17	54	114	192	6	40	113	2
Mean	569	64.6	367	186	13	41	133	181	12	38	148	4
LSD (0.05)	57	7.3	39	38	6	15	31	43	7	NS	54	NS
Late harvest												
CO89097-2	625	94.8	591	192	4	30	158	400	0	30	1	1
D. R. Norland	632	96.2	608	234	5	38	191	374	3	20	0	1
Mazama	604	97.1	586	324	4	52	269	263	4	13	0	0
NDO4300-1	636	96.4	613	241	4	40	198	372	2	17	0	5
Red LaSoda	695	92.9	646	185	8	34	143	461	6	36	2	4
Sangre 14	547	86.9	475	192	7	40	145	283	2	70	0	
Winema	547	93.8	514	145	2	22	121	368	7	24	2	0
Yukon Gold	537	96.9	520	193	2	30	161	327	2	14	0	0
Mean	603	94.4	569	213	5	36	173	356	3	28	0	2
LSD (0.05)	48	3.2	48	35	2	14	33	55	NS	18	NS	4
Difference												
CO89097-2	33	18.5	140	18	-4	9	13	121	-19	3	-84	-8
D. R. Norland	38	39.3	271	73	-4	1	75	198	-9	-12	-209	-3
Mazama	6	14.8	95	27	-3	4	26	67	-4	-27	-54	-3
NDO4300-1	46	23.7	184	11	-4	-7	22	174	-11	-29	-99	
Red LaSoda	100	49.4	388	48	-12	-8	68	340	-4	0	-285	2
Sangre 14	85	26.8	201	1	-21	-23	46	200	-13	40	-142	0
Winema	-34	39.2	196	31	-4	6	28	166	-6	-25	-194	-7
Yukon Gold	-2	26.5	143	8	-14	-24	47	135	-4	-26	-113	-2
Mean	34	29.8	202	27	-8	-5	40	175	-9	-10	-147	-3

Table 2. Russet potato varieties harvested after 90 or 122 days of vine growth: yield, grade, and difference between the harvest dates. Malheur Experiment Station, Oregon State University, Ontario, OR 2001.

Variety	Total Yield	Percent No. 1	Total No. 1	Marketable	>12 oz	6 to 12 oz	4 to 6 oz	<4 oz	U.S. No. 2	cull	rot	Specific gravity	Stem-end fry color
	cwt/acre	%	---cwt/acre---										%
Early Harvest													
Alturas (A82360-7)	500	71.5	358	439	76	198	84	40	81	13	2	1.0816	48.6
A90586-11	555	62.8	347	492	145	164	39	24	145	30	2	1.0873	36.7
Wallowa (AO87277-6)	570	65.6	374	504	186	157	30	16	130	36	6	1.0896	42.8
AO92023-3	605	77.5	469	550	335	119	16	10	80	33	5	1.0764	36.8
Gem Russet (A8495-1)	536	83.7	449	478	115	260	74	39	30	3	8	1.0887	48.5
Klamath R(AO85165-1)	600	67.8	406	544	214	166	26	28	137	18	3	1.0714	31.0
Russet Burbank	571	35.9	204	406	72	101	30	28	202	127	3	1.0774	30.6
Shepody	525	51.8	273	420	163	89	21	8	147	86	5	1.0809	41.9
Umatilla Russet	569	67.0	382	491	228	120	33	13	109	53	5	1.0860	41.7
Mean	559	64.9	362	481	171	153	39	23	118	44	4	1.0821	39.9
LSD (0.05)	40	7.0	48	40	35	33	26	8	34	24	NS	0.0042	3.4
Late harvest													
Alturas (A82360-7)	611	70.6	431	512	84	217.7	129	61	81	38		1.0859	49.0
A90586-11	614	63.4	389	540	199	150	40	19	151	52	3	1.0960	30.8
Wallowa (AO87277-6)	602	71.8	432	553	205	194	33	12	121	35	1	1.0924	39.2
AO92023-3	545	75.1	410	479	311	81	19	10	69	55	1	1.0788	31.7
Gem Russet (A8495-1)	514	86.4	444	468	129	220	96	35	24	10	0	1.0861	47.6
Klamath R(AO85165-1)	608	66.3	401.6	535	237	126	38	23	133	50	0	1.0722	31.4
Russet Burbank	632	34.3	217	410	103	81	33	30	193	169	24	1.0792	33.1
Shepody	512	52.7	267	385	135	102	31	10	117	118		1.0864	36.2
Umatilla Russet	577	61.1	353	479	214	110	29	15	126	82	0	1.0854	42.0
Mean	580	64.6	372	485	180	142	50	24	113	68	3	1.0847	37.9
LSD (0.05)	49	7.5	47	48	40	24	16	10	42	34	4	0.0062	7.5
Difference													
Alturas (A82360-7)	112	-0.9	73	74	8	20	46	21	0	26	-2	0.0042	0.3
A90586-11	59	0.7	42	48	54	-14	2	-5	7	22	0	0.0087	-6.0
Wallowa (AO87277-6)	32	6.2	58	49	19	37	3	-4	-9	-1	-5	0.0028	-3.6
AO92023-3	-60	-2.4	-60	-71	-24	-39	3	0	-11	22	-4	0.0024	-5.2
Gem Russet (A8495-1)	-21	2.7	-4	-10	14	-40	22	-3	-6	6	-7	-0.0025	-0.8
Klamath R(AO85165-1)	8	-1.6	-5	-10	23	-40	12	-5	-5	33	-3	0.0008	0.4
Russet Burbank	62	-1.6	13	4	31	-20	2	3	-10	42	21	0.0017	2.6
Shepody	-13	0.9	-6	-36	-29	13	10	2	-30	32	-4	0.0054	-5.7
Umatilla Russet	8	-5.9	-29	-12	-13	-10	-5	2	17	29	-4	-0.0006	0.4
Mean	21	-0.2	9	4	9	-10	10	1	-5	23	-0	0.0025	-2.0

POTATO VARIETY TRIALS 2001

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Introduction

Malheur County currently grows about 9,500 acres of potatoes, with an average yield of 402 cwt/acre. Potatoes are grown under contract with potato processors for frozen products for the food service industry. There is very little production for fresh pack or open market, and growers do not have storages 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. The varieties grown are mainly 'Shepody', for early harvest and 'Ranger Russet' and 'Russet Burbank' for late harvest. Harvest begins in July, providing potatoes to processing plants straight from the field. The early-harvested fields, about 3,000 acres, are mostly furrow irrigated. For late harvest, August through October, about 6,500 acres are mostly sprinkler irrigated.

Small acreages of some new varieties are contracted by processors each year to study the feasibility of writing contracts for 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 percentage of U.S. No. 1 tubers must be high, and 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 diseases, water stress, and heat. It should begin to bulk its tubers early if it is a variety for early harvest. Or, if it is a late-harvest variety, it should be resistant to early vine death, known as the "early die" syndrome. Early die is caused by a disease complex of common soil fungi, mainly *Verticillium* and *Fusarium*. A late-harvest variety should continue tuber development late in the growing season.

Potato variety development trials at Malheur Experiment Station in 2001 included an 8-Hill trial of 110 long russet clones from the USDA Agricultural Research Service (ARS) potato breeding program at Aberdeen, Idaho; the Oregon Preliminary Yield trial with 95 entries; the Oregon Statewide trial with 20 entries; the Western Regional Early-harvest Trial with 17 entries; and the Western Regional Late-harvest trial with 17 entries.

Materials and Methods

The five potato variety trials were grown under sprinkler irrigation on Owyhee silt loam, where winter wheat was the previous crop. The wheat stubble was flailed, the field was irrigated, and disked, then 100 lb P/acre and 50 lb N/acre were broadcast. In the fall, the field was ripped with Telone II injected at 22 gal/acre, and the field was bedded on 36-inch row spacing. A soil test taken on April 17, 2001 showed available nitrate plus ammonia was 89 lb N/acre in the top 2 ft of soil, and the top ft of soil had 24 ppm extractable P, 262 ppm K, 1 percent organic matter, and pH 7.6.

Seed of all varieties was hand cut into 2-oz seed pieces and treated with Tops-MZ-Gaucho dust. The Western Regional Early-harvest trial was planted April 12, 2001, and the other trials were planted April 19 and 20. The 8-Hill trial was unreplicated, the Preliminary Yield Trial had two replicates, and the Statewide, Western Regional Early-harvest, and Western Regional Late-harvest trials each had four replicates. Plots were planted using a two-row cup planter with seed spacing 9 inches in the row, with rows 36 inches apart. The potato rows were sidedressed to provide 60 lb N/acre, 50 lb K/acre, 50 lb S/acre, 25 lb Mg/acre, 8 lb Zn/acre, 1 lb Mn/acre, and 1 lb B/acre. After planting, hills were formed over the rows with a Lilliston rolling cultivator. Prowl at 1 lb ai/acre plus Dual at 2 lb ai/acre, in 30 gal/acre spray mix, was applied and incorporated with the Lilliston on May 1. Matrix herbicide was applied at 1.2 oz/acre on May 7.

Potatoes in the Western Regional Early-harvest Trial had full emergence by May 15, and later planted potatoes had full emergence by May 25. Fungicide applications to prevent late blight infection started with an aerial application of Ridomil Gold and Bravo at 1.5 pint/acre on June 14, and then with Dithane at 4 pint/acre on June 22. Powdered sulfur was applied at 30 lb/acre by airplane on July 14, and again on July 28, to control powdery mildew.

The sprinkler system was operated 18 times, with scheduling based on soil water potential measured with 6 Watermark soil moisture sensors (Irrometer Co. Inc., Riverside, CA) logged by a Hansen AM400 (M. K. Hansen Co., East Wenatchee, Wa). The AM400 unit was read daily through the summer to anticipate crop water needs, and an irrigation was applied when the average soil moisture in the potato root zone approached -60 kPa.

A petiole test taken on June 26 showed nutrient deficiencies were developing. Fertilizer was injected into the sprinkler line during an irrigation on July 3 to supply 20 lb N/acre, 0.25 lb Mn/acre, and 0.2 lb B/acre. A petiole test taken on July 11 showed nutrient deficiencies, so fertilizer was injected into the sprinkler line again on July 19 to supply 20 lb N/acre, 10 lb S/acre, 5 lb Mg/acre, 0.25 lb Zn/acre, and 0.25 lb Mn/acre. Vines were flailed in the early-harvest trial on August 13, and in the late-harvest trials on September 19.

Western Regional Early-harvest potatoes were lifted August 21 with a two-row digger that laid the tubers back onto the soil in each row, and potatoes were visually evaluated in the plots. Visual evaluations included observations of desirable traits, such as a high yield of large, smooth, uniformly shaped and sized, oblong (or "blocky") 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 tuber appearance. Tubers were placed into burlap sacks and hauled to a barn where they were kept under tarps until grading. At grading, a 20-tuber sample from each plot was placed into refrigerated storage for processing quality tests.

The potatoes in the Preliminary Yield trial were dug on September 26, and the potatoes in the Western Regional Late-harvest, Statewide, and 8-Hill trials were dug on September 27 with the two-row digger. At 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 20 through 30 and evaluated for tuber quality traits. 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.

Results and Discussion

Dry weather kept late blight from developing in 2001. No powdery mildew or mite problems were observed in the field, probably due to the sprinkler irrigation keeping the canopy environment moist. Precipitation for April through September was 2.13 inches. Potato evapotranspiration, Et_c, was measured using a U.S. Bureau of Reclamation Agrimet station at the Malheur Experiment Station. The crop Et_c for the early-harvest trial totaled 21.5 inches, and the trial received 22.0 inches of irrigation plus precipitation, or 102 percent of Et_c. For the late-harvest trials Et_c totaled 26.8 inches, and the trials received 27.4 inches of irrigation plus precipitation, or 102 percent of Et_c.

8-Hill Trial

Eight hills were grown of each of 110 clones selected for long, russeted tubers from the Aberdeen ARS potato breeding program. Of the 110 clones, the top 20 were selected, based on tuber type, yield, and grade, for processing quality determination (Table 1). Several of the clones had high yields, good processing quality, and were sufficiently free from defects to warrant growing them in future trials. The clone 'A97210-10' yielded a total of 1,003 cwt, with 81 percent U.S. No. 1 grade tubers, with specific gravity of 1.092 g/cm^3 and average fry color of 50.2 percent light reflectance. The clone 'A97019-2' yielded 993 cwt total, with 88 percent U.S. No. 1 grade, with specific gravity 1.102, and fry color 44 percent light reflectance.

Preliminary Yield Trial

In the Preliminary Yield Trial, 95 numbered clones were compared to 'Russet Burbank', 'Ranger Russet', 'Shepody', 'Norkotah', and 'Umatilla Russet' (Table 2). The Oregon potato variety selection committee kept 12 clones to advance to the Statewide trial for

2002. The clones that were kept, 'AO96382-3', 'AO97178-1', 'AO97318-2', 'AO97133-2', 'AO97278-3', 'AO97303-2', 'AO97109-3', 'AO97118-3', 'AO97131-3', 'AO97143-1', 'AO97171-4', and 'AO97175-13', are marked with a asterisk in the entry list. These clones yielded well over the four locations (Hermiston, Klamath Falls, Ontario, and Powell Butte), had high percent U.S. No. 1 grade tubers, and had high specific gravity and light fry color needed for processing.

Oregon Statewide Trial

In the Oregon Statewide Trial, five clones, 'AO94110-203', 'AO96160-3', 'AO96164-1', 'AO96176-3' and 'AO96177-6' were kept by the variety selection committee (Table 3). 'AO94110-203' will advance to the Western Regional Early and Late Harvest trials for 2002. 'AO94110-203' produced a total yield of 690 cwt/acre, with 84 percent U.S. No. 1 grade, good specific gravity of 1.108 g/cm^3, and an average fry color reading of 46 percent light reflectance. 'AO96160-3' produced total yield of 582 cwt/acre, with 90 percent U.S. No. 1, specific gravity of 1.100 g/cm^3, and fry color of 51 percent light reflectance. 'AO96164-1' produced total yield of 602 cwt/acre, with 80 percent U.S. No. 1, specific gravity of 1.098 g/cm^3, and fry color of 50 percent light reflectance., 'AO96176-3' produced total yield of 612 cwt/acre, with 86 percent U.S. No. 1, specific gravity of 1.088 g/cm^3, and fry color of 47 percent light reflectance. 'AO96177-6' produced total yield of 605 cwt/acre, with 77 percent U.S. No. 1, specific gravity of 1.104 g/cm^3, and fry color of 47 percent light reflectance. 'Russet Burbank' had 55 percent sugar ends, far more than any other variety.

Western Regional Early-harvest Trial

In the Western Regional Early-harvest trial, 'A8893-1' with 619 cwt/acre total yield, 'A90586-11' with 612 cwt/acre, 'AC87138-4' with 573 cwt/acre, 'AC87079-3' with 572 cwt/acre, 'Russet Burbank' with 568 cwt/acre, and 'A9045-7' with 564 cwt/acre were among the highest total yields (Table 4). All of those clones except 'Russet Burbank' had acceptable specific gravity and fry color, and no sugar ends. 'Russet Burbank' produced 10 percent sugar ends. In production of marketable tubers (the total of U.S. No.1 plus U.S. No. 2 grades) 'A8893-1' with 579 cwt/acre, 'A90586-11' with 538 cwt/acre, 'A9045-7' with 529 cwt/acre, and 'AC87079-3' with 521 cwt/acre were among the highest. 'Russet Burbank' produced 110 cwt/acre cull tubers, which was significantly more culls than any other variety in this trial. 'AC87138-4' produced 47 cwt/acre cull tubers.

Western Regional Late-harvest Trial

In the Western Regional Late-harvest trial, among the highest for total yield, 'A90586-11' with 738 cwt/acre, 'AC87079-3' with 679 cwt/acre, 'A8893-1' with 678 cwt/acre, and 'A9045-7' with 678 cwt/acre (Table 5). The clone 'A90586-11' with 668 cwt/acre marketable yield, 'A8893-1' with 649 cwt/acre, 'A9045-7', with 646 cwt/acre, and 'AC87079-3' with 631 cwt/acre produced among the highest marketable yields. The clones 'A8893-1', 'A9014-2', 'AC87079-3', 'AC87138-4', 'TXNS102', and 'TXNS296' were advanced out of the trial, and 'AC91014-2', 'AO92017-6', and 'ATX9202-3RU' were dropped from further testing. All of the other entries will remain in the trials for 2002 to be evaluated an additional year. 'Russet Burbank' had 45 percent sugar ends, more than any other variety.

Table 1. Yield, grade, and processing quality of the top 20 clones out of 110 early selections in an unreplicated 8-Hill Trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

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. 1 <4 oz	U.S. No. 2	Cull	Length-to-width ratio	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	---------------	----------	cwt/acre	----------	---------------	---------------			%	%
A97203-1	707.1	86.1	609.1	236.9	372.2	7.5	90.5	0.0	1.96	1.09531	36.7	0
A97207-3	876.3	89.5	783.8	383.8	400.0	21.5	70.2	0.0	1.58	1.10049	53.5	0
A97239-5	908.2	95.1	863.7	431.2	432.5	15.0	29.5	0.0	1.67	1.11049	42.5	0
A97237-9	825.0	91.1	751.4	387.2	364.2	34.6	39.0	0.0	1.96	1.09272	47.8	0
A96573-6	815.8	88.6	722.9	356.7	366.1	31.2	61.7	0.0	1.71	1.09256	42.1	0
A97299-1	782.6	82.2	643.2	463.9	179.3	9.4	109.4	0.0	1.93	1.10003	46.9	0
A97019-2	993.2	88.3	877.0	680.5	196.5	15.7	100.4	0.0	1.73	1.10155	43.9	0
A97209-4	809.2	90.3	730.8	339.5	391.3	47.9	30.5	0.0	1.69	1.10160	41.9	0
A97210-10	1003.3	80.5	807.6	556.8	250.7	15.2	180.5	0.0	1.64	1.09210	50.2	0
A97229-1	835.4	89.6	748.5	164.3	584.2	14.5	72.4	0.0	1.80	1.08463	34.3	10
A97223-9	775.9	94.6	734.2	471.4	262.8	8.7	32.2	0.0	1.62	1.10673	50.4	0
A97140-8	939.4	88.5	831.8	49.4	782.4	77.0	30.7	0.0	1.62	1.09227	42.5	0
A97130-8	841.0	89.9	755.8	440.0	315.8	3.6	81.6	0.0	1.78	1.09222	48.1	10
A96109-5	989.3	89.6	886.4	487.1	399.3	21.5	81.3	0.0	1.34	1.09128	47.6	0
A96110-4	549.6	91.9	505.1	173.3	331.8	36.1	8.5	0.0	1.72	1.09203	47.7	0
A96111-2	840.2	93.6	786.7	40.9	745.8	36.8	16.7	0.0	1.62	1.09000	39.5	10
A96549-3	622.2	89.9	559.5	179.1	380.4	31.5	31.2	0.0	1.92	1.08974	39.6	0
A96552-7	697.0	87.7	611.3	136.2	475.0	19.1	66.6	0.0	1.74	1.10695	46.2	0
A97110-14	831.0	92.6	769.3	60.7	708.6	56.9	4.8	0.0	1.77	1.08323	45.2	0
A96108-12	914.5	87.1	796.9	244.7	552.2	58.6	22.5	36.5	1.44	1.09574	42.5	10

Table 2. Preliminary Yield Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

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. 1 <4 oz	U.S. No. 2	Cull	Length-to-width ratio	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	cwt/acre								%	%
R. Burbank	585	61	359	75	284	32	165	30	1.86	1.086	34.1	15
Ranger	536	71	378	124	255	22	123	12	1.8	1.097	44	0
Shepody	497	61	304	164	140	14	134	45	1.66	1.091	41.9	5
Norkotah	515	88	454	141	313	25	35	0	1.77	1.073	28.7	10
Umatilla	575	77	441	165	276	24	102	7	1.8	1.099	49.3	0
NDO3989-1	410	89	366	77	289	33	12	0	1.62	1.091	42.2	0
AO96192-1	522	60	314	100	215	19	144	45	1.94	1.083	39	0
AO96314-2	492	82	405	139	266	9	72	5	1.94	1.096	42.4	0
AO96314-4	585	83	483	180	303	20	67	15	1.9	1.107	40.9	0
AO96342-2	526	78	408	11	396	69	49	0	1.9	1.088	41.4	0
AO96362-1	353	50	177	102	74	8	121	47	1.84	1.106	47.9	0
AO96362-4	457	77	349	91	259	48	49	10	1.84	1.101	49.2	0
AO96362-5	507	84	424	99	326	45	32	6	1.78	1.086	39.5	0
AO96362-6	477	70	335	126	209	14	128	0	1.87	1.098	47.4	0
AO96382-3*	727	77	564	220	344	47	113	4	1.92	1.093	48.5	0
AO97178-1*	470	83	392	68	324	35	39	5	1.78	1.087	40	5
AO97247-6	577	75	434	253	180	24	100	20	1.64	1.093	49.4	0
AO97285-2	588	87	512	112	400	35	36	5	1.59	1.095	42.9	0
AO97314-2	539	74	399	111	288	34	101	6	1.63	1.096	42.5	5
AO97318-2*	740	68	501	149	352	52	177	10	1.46	1.088	45.2	0
AO97318-4	678	80	542	319	223	26	95	15	1.82	1.095	46.7	0
AO97318-5	621	84	523	196	327	31	68	0	1.91	1.089	40	5
AO97332-2	630	77	487	131	356	43	100	0	1.66	1.101	43.9	0
AO97405-2	552	72	397	25	372	96	54	5	1.96	1.100	46.8	0

*Advanced to 2002 Statewide Trial based on the results from four locations.

Table 2. *(continued)* Preliminary Yield Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

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. 1 <4 oz	U.S. No. 2	Cull	Length-to-width ratio	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	cwt/acre								%	%
AO97133-2*	546	84	459	39	421	56	29	1	1.73	1.098	50.1	0
AO97206-2	375	67	250	34	215	84	37	4	1.9	1.091	50	0
AO97270-3	552	82	452	152	300	56	41	4	1.58	1.099	42.9	0
AO97278-1	515	84	430	112	318	43	33	9	1.53	1.094	48.6	0
AO97284-2	530	68	360	163	197	16	152	1	1.73	1.091	46.8	0
AO97278-3*	708	56	400	238	162	23	281	4	1.83	1.095	49.1	0
AO97278-6	587	83	488	104	384	27	72	0	1.7	1.079	44.9	5
AO97303-2*	602	89	534	142	391	24	42	3	1.92	1.089	39.4	0
AO97313-1	469	80	375	170	205	34	60	0	1.66	1.092	43.7	0
AO97333-2	637	73	467	118	349	52	118	0	1.72	1.091	46	0
AO97333-4	638	71	455	0	455	117	51	15	1.72	1.104	49.7	0
AO97333-7	449	64	290	68	221	31	128	0	1.84	1.077	30.6	0
AO97333-8	519	89	462	132	330	25	32	0	1.52	1.106	51.2	0
AO97334-4	607	83	506	166	341	49	48	3	1.72	1.086	49.3	0
AO97334-6	713	77	550	138	412	57	106	0	1.48	1.100	51.3	0
AO97335-10	422	84	353	106	247	20	48	0	1.68	1.089	35	5
AO97335-2	505	85	427	156	271	55	18	5	1.66	1.091	38.8	0
AO97335-3	463	88	409	259	150	19	28	7	1.73	1.085	46.3	0
AO97335-4	362	89	324	43	281	25	12	1	1.92	1.096	41.7	5
AO97336-3	482	69	334	101	233	28	120	0	1.9	1.092	44.5	5
AO97336-5	579	76	438	111	328	36	100	5	1.79	1.097	46.5	0
AO97338-1	524	57	299	102	197	37	167	21	2.11	1.082	46.1	0
AO97338-6	534	81	433	185	248	21	55	25	1.72	1.094	39.6	0
AO97109-3*	484	88	428	124	303	22	35	0	1.72	1.092	41	0
AO97110-2	602	92	551	200	351	13	37	0	1.7	1.111	46	0
AO97112-2	603	80	482	219	263	33	75	13	1.88	1.091	43.7	0
AO97112-3	531	77	408	123	285	37	56	30	1.73	1.079	52.3	0
AO97113-7	603	79	476	233	243	36	77	14	1.87	1.107	47.5	0

*Advanced to 2002 Statewide Trial based on the results from four locations.

Table 2. *(continued)* Preliminary Yield Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Variety	Total yield	U.S. No. 1 Percent No. 1	Total	>12 oz	4-12 oz	<4 oz	U.S. No. 2	Cull	Length-to-width ratio	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	---	---	cwt/acre	---	---	---			%	%
AO97113-9	459	71	326	30	296	93	26	13	1.69	1.113	54	0
AO97116-3	412	80	329	68	261	24	53	6	2.07	1.082	40.8	0
AO97118-3*	465	78	363	68	295	66	35	0	1.65	1.093	51.5	0
AO97120-1	418	78	328	96	232	24	43	22	1.88	1.095	44.3	0
AO97120-3	418	72	301	41	260	94	24	0	1.63	1.104	49.9	0
AO97122-5	468	63	295	8	287	171	2	0	1.67	1.094	49.7	0
AO97122-6	521	80	416	66	349	23	82	0	1.88	1.087	52	0
AO97128-1	0	82	339	4	335	33	41	0	2	1.104	41.4	0
AO97128-4	657	69	451	169	282	67	137	2	1.75	1.095	51.1	0
AO97130-1	559	71	397	127	270	42	117	2	1.83	1.092	42.5	5
AO97130-2	600	79	471	139	333	51	70	7	1.58	1.102	43.2	0
AO97130-4	624	88	548	229	319	10	66	0	1.58	1.090	45.1	0
AO97131-3*	546	77	422	84	338	29	81	14	1.88	1.091	45.2	0
AO97140-4	553	79	439	181	258	12	87	14	1.76	1.091	43.4	0
AO97143-1*	608	81	494	277	217	16	92	5	1.79	1.104	47.3	5
AO97144-3	687	52	359	196	162	13	233	83	1.94	1.097	38.2	5
AO97149-1	589	83	488	58	430	54	44	3	1.69	1.112	49	0
AO97166-2	573	83	474	117	357	29	67	4	1.39	1.099	51.6	0
AO97170-3	605	82	498	259	239	17	90	0	1.61	1.092	51.6	0
AO97171-3	428	87	373	138	235	34	21	0	2.08	1.086	49.6	0
AO97171-4*	575	74	424	114	310	22	120	9	1.72	1.103	46.7	0
AO97173-3	447	73	326	190	136	4	55	62	1.96	1.094	45.2	0
AO97175-1	552	93	514	235	279	14	24	0	1.69	1.091	42.1	0
AO97175-10	541	80	430	167	263	23	83	5	1.9	1.101	53.3	0
AO97175-13*	456	75	342	7	335	84	30	0	1.48	1.096	51.9	0
AO97175-6	627	77	481	134	348	50	95	0	1.54	1.098	56.1	0
AO97175-7	520	89	464	102	362	14	41	0	2.05	1.093	46.2	5
AO97177-2	696	67	466	221	245	26	154	49	1.71	1.096	44	0

*Advanced to 2002 Statewide Trial based on the results from four locations.

Table 2. *(continued)* Preliminary Yield Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2001

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. 1 <4 oz	U.S. No. 2	Cull	Length-to-width ratio	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	---cwt/acre---								%	%
AO97191-1	561	82	462	118	344	45	45	9	1.73	1.097	48.8	0
AO97192-1	590	73	433	264	169	24	86	48	1.82	1.090	44.5	0
AO97195-1	557	76	422	149	273	29	85	21	1.88	1.092	51.7	0
AO97197-2	629	75	469	29	441	113	43	4	1.59	1.104	49.4	0
AO97198-8	615	53	324	114	210	30	187	75	1.78	1.093	46.6	0
AO97199-1	579	79	455	42	413	91	33	0	1.41	1.099	51.3	0
AO97199-2	561	73	411	159	252	17	133	0	1.79	1.101	48.3	0
AO97199-3	721	74	537	100	437	47	131	6	1.86	1.101	41.4	0
AO97227-2	555	81	449	97	352	77	24	4	1.71	1.091	39.1	0
AO97243-5	617	69	429	45	384	38	145	5	1.54	1.094	46.8	0
AO97258-1	629	78	492	84	408	44	93	0	1.85	1.101	39.3	0
AO97259-1	553	85	468	24	444	54	26	3	1.42	1.109	49.3	0
AO97260-2	458	83	380	14	366	68	10	0	1.87	1.090	45.9	0
AO97263-5	582	60	351	236	115	12	187	33	1.72	1.104	52	0
AO97287-7	497	77	383	29	354	82	26	5	1.51	1.098	48.3	0

Table 3. Oregon Statewide Trial: yield, grade, and processing quality of potato varieties grown at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

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. 1 <4 oz	U.S. No. 2	Cull	Length: width ratio	Specific gravity	Average fry color, light reflectance	Sugar ends
	cwt/acre	%	-----	-----	cwt/acre	-----	-----	-----			%	%
Russet Burbank	611	56	339	119	221	50	124	98	1.90	1.079	29.2	55.0
Ranger Russet	618	67	416	203	213	17	144	41	1.81	1.102	41.8	7.5
Shepody	600	61	358	156	201	16	155	71	1.59	1.089	36.5	30.0
Norkotah Russet	498	81	406	135	270	24	62	7	1.87	1.074	27.3	35.0
Umatilla Russet	548	74	405	180	225	19	104	20	1.92	1.092	43.0	2.5
AO92017-6	657	82	536	327	209	11	98	12	1.88	1.094	37.7	10.0
AO92019-4	414	88	363	87	276	25	20	6	1.69	1.083	31.5	30.0
AO92023-3	661	84	554	351	204	12	74	20	1.82	1.081	25.5	15.0
AO94004-3	519	86	445	69	376	33	37	5	1.63	1.099	43.9	0.0
AO94110-203	690	84	582	203	379	36	71	2	1.65	1.108	46.3	0.0
AO96060-1	652	86	564	131	432	28	56	4	1.62	1.093	37.2	0.0
AO96065-7	538	83	449	52	396	42	43	6	1.59	1.100	44.0	5.0
AO96160-3	582	90	522	46	476	26	32	2	1.72	1.100	51.4	0.0
AO96164-1	602	80	481	150	331	23	81	18	1.71	1.098	49.8	0.0
AO96165-2	636	84	537	161	376	35	61	2	1.76	1.093	41.1	7.5
AO96165-9	606	80	483	85	397	47	69	6	1.82	1.087	30.9	15.0
AO96176-3	612	86	526	160	365	30	56	1	1.83	1.088	46.7	0.0
AO96177-6	605	77	466	357	110	7	103	28	1.91	1.104	46.6	2.5
AO96262-1	612	77	475	221	254	23	82	31	1.83	1.094	38.1	10.0
AO96272-1	644	71	459	207	252	25	131	29	1.97	1.097	40.3	0.0
Mean	595	79	468	170	298	26	80	20	1.78	1.093	39.4	11.3
LSD (0.05)	76.5	7.4	79.2	59.3	66	11	30.7	35.5	0.123	0.005	3.6	11.2

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 potatoes are often limited. Several herbicides currently registered for use in other crops show promise for use in potatoes. Spartan (sulfentrazone) and Valor (flumioxazin) represent a herbicide mode of action that is not currently used in potatoes and offer more effective hairy nightshade control than current herbicide programs. Outlook (dimethenamid-p) is similar to Dual but controls a larger spectrum of weeds. Trials were conducted to evaluate new herbicides for weed control in potatoes.

Methods

Five trials were conducted at the Malheur Experiment Station to evaluate new herbicides for weed control efficacy and crop tolerance in potatoes. All trials were sprinkler irrigated. Potatoes were planted April 17 and 18 in a silt loam soil with pH 7.6 and 1.4 percent organic matter (OM). 'Russet Burbank' seed pieces were planted every 9 inches in 36-inch-wide rows. Seed pieces were treated with Tops MZ + Gaucho at seed cutting. Experimental plots were four rows wide and 30 ft long. Plots were sidedressed with fertilizer (60 lb N, 25 lb Mg, 8.0 lb Zn, 1.0 lb B, 1.0 lb Mn, and 1.0 lb Cu/acre) on April 26 and beds were reshaped with a Lilliston cultivator on May 7. Preemergence herbicides were applied on May 9 or May 10 and incorporated with overhead irrigation on May 10. Postemergence herbicide applications were made on May 29. Treatments were applied with a CO_2-pressurized backpack sprayer delivering 20 gal/acre at 30 psi. Plots were irrigated with sprinklers according to crop requirements throughout the season. Potatoes were sprayed with Ridomil plus Bravo (June 14) and Dithane (June 22) to prevent late blight and with sulfur dust (July 14 and 28) to control powdery mildew. Potato injury and weed control were evaluated throughout the growing season and tuber yields were taken by harvesting the center two rows of each plot. Potatoes were harvested on September 5, 6, and 7. Potatoes were graded for yield and size on September 10-13 and 16-18.

Potato Response and Weed Control with Spartan and Valor Combinations

Spartan was applied alone at rates from 0.063 to 0.25 lb ai/acre and at 0.125 lb ai/acre in combination with other herbicides. Valor was applied alone at rates from 0.047 to 0.125 lb ai/acre and at 0.094 lb ai/acre in combination with other herbicides. Spartan and Valor were applied in combinations with Eptam, Dual Magnum, Outlook, and Prowl. Spartan and Valor treatments were compared to Eptam, Dual Magnum, Outlook, and

Prowl alone, and to tank mixtures of Dual Magnum plus Matrix and Dual Magnum plus Sencor. Matrix was inadvertently applied at one third the desired rate. Treatments were replicated four times. Weed biomass production was determined by harvesting weeds from 5 ft of one center row in each plot and separating the weed samples by species. Biomass samples were dried and weighed.

Weed Control with Outlook Combinations

Combinations of Outlook with herbicides currently registered for use in potatoes were evaluated for weed control efficacy. Outlook was combined with Prowl, Sencor, Matrix, Eptam, and Prowl plus Sencor. Outlook combinations were compared with Prowl plus Sencor and Prowl plus Matrix. Treatments were replicated three times. Weed biomass production was also determined in this trial as previously described.

Potential Antagonism Between Valor and Prowl

Research in 2000 suggested that combinations of Valor with Prowl provided less control of redroot pigweed than Valor applied alone. These results indicated that Prowl may antagonize the activity of Valor. In order to test this hypothesis, Valor at two rates (0.047 and 0.94 lb ai/acre) and Prowl at two rates (0.5 and 1.0 lb ai/acre) were applied alone and in combinations. Select was applied on May 29 to control any barnyardgrass in the plots. Broadleaf weed control was evaluated early and late in the growing season. Treatments were replicated three times.

Volunteer Barley Control with Select

Barley seed was broadcast over the entire trial and incorporated with the Lilliston on May 8. Prowl (0.75 lb ai/acre) was applied on May 9 to control other weeds impacting the potatoes. Select treatments were applied on May 29 when potatoes were 8 inches tall and barley was an average of 7 inches tall. Treatments were replicated three times. Potato injury and barley control were evaluated throughout the season. Because the Prowl application did not control all the broadleaf weeds, redroot pigweed, common lambsquarters, and hairy nightshade control was evaluated at the end of the season.

Tolerance of 'Russet Burbank' Potatoes to Outlook Combinations

This trial was conducted to evaluate preemergence Outlook for crop injury at normal field use rates applied alone and in combination with products currently registered for use in potatoes. Outlook (dimethenamid-p) is an active isomer of the herbicide Frontier (dimethenamid) and has been submitted to the U.S. Environmental Protection Agency for registration on potatoes. Outlook was applied in combinations with Sencor, Prowl, or Matrix. Outlook treatments were compared with Matrix applied alone. Treatments were replicated four times. In previous years, Outlook applied alone at rates as high as four times the standard use rate did not result in reduced potato yields. All plots were hand weeded prior to row closure, but weeds emerging later in the season were not removed to avoid mechanical injury to the potato canopy. Lower yields in the untreated plots are likely due to weed competition.

Results and Discussion

Spring weather was conducive to early potato growth and the rapid canopy closure helped make soil-active herbicide treatments effective. July and August were extremely hot, resulting in less than ideal conditions for potato growth. Weed control plots were not fumigated the previous fall and plants died back from "early die" complex earlier than usual.

Potato Response and Weed Control with Spartan and Valor Combinations

Both Spartan and Valor were less effective in controlling weeds this year when compared to 2000. No significant injury from either herbicide was observed at any of the rates evaluated (data not shown). When comparing similar rates, Spartan generally provided greater control of redroot pigweed, common lambsquarters, and barnyardgrass compared to Valor (Table 1). Both products provided similar control of hairy nightshade with greater control at the higher rates. On June 7, Outlook provided greater redroot pigweed and hairy nightshade control than Dual Magnum, Eptam, and Prowl. Prowl provided greater common lambsquarters control than Outlook, Eptam, and Dual Magnum. Spartan or Valor applied in combination with Dual Magnum, Prowl, or Eptam provided greater than 90 percent control of all broadleaf weeds, except for Valor plus Prowl, which provided only 83 percent control of redroot pigweed. At the late evaluation on August 20, hairy nightshade control with Valor and Spartan alone or in combinations was greater than the standard treatments of Dual Magnum plus Sencor or Dual Magnum plus Matrix. The lower hairy nightshade control with Dual Magnum plus Matrix is likely attributable to the low rate of Matrix applied. Hairy nightshade control was greater in plots where barnyardgrass was not controlled because the barnyardgrass prevented hairy nightshade germination and growth.

Potato yields increased with increasing weed control (Table 2). Spartan and Valor continue to show great potential for use in potatoes. Additional research needs to be done to determine why Valor provides less weed control in Ontario than in research trials in other states. Additional research also needs to identify the reason that Spartan sometimes causes potato injury.

Weed Control with Outlook Combinations

The weed pressure in this trial was significantly less than in the previous trial. All treatments provided greater than 90 percent control of all species on June 7. On August 21 control of redroot pigweed, common lambsquarters, and barnyardgrass was greater than 92 percent with all treatments (Table 3). Prowl plus Sencor provided significantly less hairy nightshade control than the other herbicide treatments. All treatments reduced weed biomass compared to the untreated control. Potato yields were not different among herbicide treatments because all treatments provided good weed control (Table 4).

Potential Antagonism Between Valor and Prowl

Valor at either rate applied alone provided greater hairy nightshade and early pigweed control than Prowl applied alone at either rate (data not shown) . Prowl (1.0 lb ai/acre) provided greater common lambsquarters control than either rate of Valor. Combinations of Valor and Prowl provided control of redroot pigweed and common lambsquarters similar to that provided by each alone regardless of rates. The high rate of Valor with either rate of Prowl controlled hairy nightshade better than the low rate of Valor applied with the high rate of Prowl, but were not different from the low rate of Valor combined with the low rate of Prowl. While we were unable to identify antagonism between Valor and Prowl, the pattern of lower hairy nightshade control when low rates of Valor were combined with the high rate of Prowl suggests that some interaction may occur between the two products. Potato yield was strongly correlated with weed control and increased in all treatments when compared to the untreated check.

Volunteer Barley Control with Select
Volunteer barley was effectively controlled by all Select treatments (Table 5). Select applied in combination with Sencor provided quicker initial burndown of the barley and provided some control of broadleaf weeds. The addition of ammonium sulfate to Select also improved early control compared to Select alone. The preemergence application of Prowl did not adequately control the broadleaf weeds in plots treated only with Select as a postemergence treatment. Barley was extremely competitive with potatoes and reduced yields compared to plots where barley was controlled with Select (Table 6).

Tolerance of Russet Burbank Potatoes to Outlook Combinations
No injury was observed for any of the treatments evaluated (Table 7). Weed-free conditions were not present for all plots because additional weeds emerged after the plots were hand weeded and the potato canopy had formed. This resulted in weeds in plots without any herbicide applied. The presence of weeds in the untreated plots may have slightly suppressed yields in these plots. Yields were not different among any of the treatments evaluated. This was expected based on previous years of research with Outlook.

Table 1. Weed control on June 7 and August 20 and weed biomass on August 20 with preemergence Spartan and Valor combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate*	Weed control								Total weed biomass
		Redroot pigweed		Common lambsquarters		Hairy nightshade		Barnyard-grass		
		6-7	8-20	6-7	8-20	6-7	8-20	6-7	8-20	8-20
	lb ai/acre	%								g/m²
Spartan	0.063	84	78	97	97	75	76	49	26	334
Spartan	0.094	94	83	100	96	84	68	75	50	355
Spartan	0.125	94	83	99	98	85	58	83	48	312
Spartan	0.188	93	87	100	97	89	68	85	51	323
Spartan	0.25	100	78	100	96	96	76	92	54	431
Spartan + Eptam	0.125 + 3.0	100	81	100	98	99	75	99	85	75
Spartan + Dual Magnum	0.125 + 1.3	100	88	100	97	98	78	100	96	43
Spartan + Outlook	0.125 + 0.64	100	84	100	95	99	84	100	91	43
Spartan + Prowl	0.125 + 1.0	99	89	100	98	97	82	94	79	269
Dual Magnum + Matrix	0.5 + 0.005	100	95	100	91	93	43	100	98	323
Dual Magnum + Sencor	1.3 + 0.5	100	92	100	97	78	30	100	98	226
Valor	0.063	63	36	71	58	76	75	50	40	624
Valor	0.078	69	49	80	59	91	81	72	46	549
Valor	0.094	66	53	87	63	92	85	60	40	624
Valor	0.125	79	54	92	78	98	96	80	50	452
Valor + Eptam	0.094 + 3.0	91	69	97	82	100	96	98	82	151
Valor + Dual Magnum	0.094 + 1.3	97	74	93	65	100	89	99	94	280
Valor + Prowl	0.094 + 1.0	83	60	94	82	94	87	90	72	269
Valor + Outlook	0.094 + 0.64	100	92	100	95	100	99	100	94	65
Outlook	0.64	99	95	83	68	90	73	100	92	301
Dual Magnum	1.3	79	73	58	18	61	49	100	97	420
Prowl	1.0	59	61	99	91	56	13	93	83	323
Eptam	3.0	45	11	75	56	74	60	97	96	484
Untreated		0	0	0	0	0	0	0	0	721
LSD (0.05)		15	16	10	17	13	20	15	23	215

*Matrix was inadvertently applied at one third the desired rate.

Table 2. 'Russet Burbank' tuber yield and grade in response to preemergence Spartan and Valor combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate*	U.S. No. 1 4-6 oz	U.S. No. 1 6-12 oz	U.S. No. 1 >12 oz	U.S. No. 1 Total	U.S. No. 1 %	Total No. 2	Total marketable	Total yield
	lb ai/acre	---------------------cwt/acre------------------				%	-------------cwt/acre-------------		
Spartan	0.063	97	74	1	173	52	11	184	335
Spartan	0.094	104	155	11	271	65	22	294	419
Spartan	0.125	93	129	11	233	59	18	251	395
Spartan	0.188	99	145	15	258	65	12	271	397
Spartan	0.25	105	146	17	268	65	9	277	414
Spartan + Eptam	0.125 + 3.0	103	196	21	320	69	18	337	459
Spartan + Dual Magnum	0.125 + 1.3	123	177	18	318	67	19	337	473
Spartan + Outlook	0.125 + 0.64	122	165	12	298	65	14	313	457
Spartan + Prowl	0.125 + 1.0	116	155	18	288	64	18	307	449
Dual Magnum + Matrix	0.5 + 0.005	129	150	13	292	65	19	311	448
Dual Magnum + Sencor	1.3 + 0.5	111	152	11	275	62	18	293	445
Valor	0.063	80	47	2	131	44	12	143	298
Valor	0.078	81	72	1	154	47	15	169	325
Valor	0.094	90	64	4	159	50	8	167	316
Valor	0.125	100	94	3	196	53	10	206	365
Valor + Eptam	0.094 + 3.0	112	131	8	251	62	12	263	402
Valor + Dual Magnum	0.094 + 1.3	118	135	6	259	62	13	271	417
Valor + Prowl	0.094 + 1.0	106	130	4	240	59	18	258	403
Valor + Outlook	0.094 + 0.64	112	149	9	269	62	18	287	434
Outlook	0.64	113	129	8	250	58	18	268	427
Dual Magnum	1.3	11398	101	7	206	63	15	221	347
Prowl	1.0	110	101	5	217	56	12	229	375
Eptam	3.0	97	93	7	198	54	11	209	367
Untreated		45	23	1	70	27	2	72	250
LSD (0.05)		17	34	10	45	9	9	47	54

*Matrix was inadvertently applied at one third the desired rate.

Table 3. Potato injury on June 7 and visual weed control and weed biomass on August 21 with Outlook combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	Potato injury	Weed control: Redroot pigweed	Weed control: Common lambsquarters	Weed control: Hairy nightshade	Weed control: Barnyard-grass	Total weed biomass
	lb ai/acre	%	%	%	%	%	g/m²
Outlook + Prowl	0.64 + 1.0	0	100	100	92	100	4.3
Outlook + Sencor	0.64 + 1.0	0	100	100	86	98	19.4
Outlook + Matrix	0.64 + 0.016	2	95	92	90	96	31.2
Outlook + Eptam	0.64 + 3.0	0	100	98	98	100	1.7
Outlook + Prowl + Sencor	0.64 + 1.0 + 0.5	0	100	100	97	100	15.1
Prowl + Sencor	1.0 + 0.5	0	100	100	69	100	151.8
Prowl + Matrix	1.0 + 0.016	0	99	100	95	100	8.6
Untreated		0	0	0	0	0	412
LSD (0.05)		NS	3	7	14	3	162.5

Table 4. Tuber yield and quality in response to preemergence Outlook combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	U.S. No. 1: 4-6 oz	U.S. No. 1: 6-12 oz	U.S. No. 1: >12 oz	U.S. No. 1: Total	U.S. No. 1: %	Total No. 2	Total marketable	Total yield
	lb ai/acre	cwt/acre	cwt/acre	cwt/acre	cwt/acre	%	cwt/acre	cwt/acre	cwt/acre
Outlook + Prowl	0.64 + 1.0	134	165	15	314	63	31	345	499
Outlook + Sencor	0.64 + 1.0	136	172	29	337	69	28	365	485
Outlook + Matrix	0.64 + 0.016	119	183	28	330	70	31	361	470
Outlook + Eptam	0.64 + 3.0	116	173	22	311	65	30	342	484
Outlook + Prowl + Sencor	0.64 + 1.0 + 0.5	119	165	22	305	66	25	330	471
Prowl + Sencor	1.0 + 0.5	113	186	19	318	66	28	346	485
Prowl + Matrix	1.0 + 0.016	126	168	28	322	64	29	351	506
Untreated		69	45	3	117	38	22	139	308
LSD (0.05)		NS	40	NS	44	12	21	53	71

Table 5. Volunteer barley control with postemergence herbicides, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

		Injury		Barley control			Redroot pigweed	Common lambsquarters	Hairy nightshade
Treatment*	Rate	5-31	6-7	6-7	6-13	9-11	9-11	9-11	9-11
	lb ai/acre	-----------------------------------					%------------------------------		
Select + COC	0.125 + 1 qt	0	0	65	85	98	43	83	67
Select + COC + AMS	0.125 + 1 qt + 2.5 lb	3	0	79	96	99	42	82	66
Select + Sencor + COC	0.125 + 0.38 + 1 qt	7	7	82	91	100	82	100	78
Untreated		0	0	0	-	-	68	96	94
LSD (0.05)		NS	NS	3	NS	NS	13	16	24

*COC = crop oil concentrate, AMS = ammonium sulfate.

Table 6. Potato yield in response to postemergence herbicide applications, Malheur Experiment Station, Oregon State University, Ontario, OR, 2000.

		U.S. No. 1					Total	Total	Total
Treatment*	Rate	4-6 oz	6-12 oz	>12 oz	Total	%	No. 2	marketable	yield
	lb ai/acre	---------------cwt/acre			---------------	%	----------cwt/acre		----------
Select + COC	0.125 + 1 qt	112	93	10	216	48	32	249	448
Select + COC + AMS	0.125 + 1 qt + 2.5 lb	120	151	10	281	59	33	314	482
Select + Sencor + COC	0.125 + 0.38 + 1 qt	127	126	7	259	57	30	290	459
Untreated		32	13	0	45	18	8	53	169
LSD (0.05)		50	53	13	69	19	NS	62	143

*COC = crop oil concentrate, AMS = ammonium sulfate.

Table 7. Potato injury and yield in response to preemergence Outlook combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

		U.S. No. 1					Total	Total	Total
Treatment	Rate	4-6 oz	6-12 oz	>12 oz	Total	%	No. 2	marketable	yield
	lb ai/acre	---------------cwt/acre			---------------	%	----------cwt/acre		----------
Outlook	0.64	126	193	17	337	68	20	357	497
Outlook + Sencor	0.64 + 0.5	122	199	38	358	71	16	375	504
Outlook + Prowl	0.64 + 1.0	133	196	19	348	68	13	361	509
Outlook + Matrix	0.64 + 0.016	132	191	18	342	67	11	353	508
Matrix	0.016	131	184	31	346	68	24	369	510
Untreated		130	163	22	315	68	14	329	466
LSD (0.05)		NS	NS	NS	NS	NS	5	NS	NS

INVASIVE WEED CONTROL WITH PLATEAU® AND OASIS®

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Ontario, OR, 2001

Introduction

Invasive species continue to spread across rangeland. Once established, invasive species often have a competitive advantage over native plants. Invasive grass species like downy brome and medusahead rye 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 either downy brome or medusahead burn on a regular basis. Native species not adapted to frequent burning are further eliminated, resulting in monocultures of the invading species.

Other invasive species like hoary cress (whitetop) are able to compete with native vegetation because of extensive root systems that can use water from deep in the soil profile. Hoary cress generally establishes at disturbed sites and is then able to spread by its root system. Because it is perennial and its root system contains nutrient reserves, it can be very difficult to control.

A new herbicide, imazapic, has shown promise for control of noxious weeds in rangeland. Imazapic is the active ingredient in Plateau and is combined in a premix with 2,4-D ester in Oasis. Imazapic has been shown to be fairly selective to seeded desirable grass species. The ability to control invasive species without injury to newly seeded grasses would be a great tool for reclaiming badly infested sites. Imazapic needs to be tested under local conditions to determine its effectiveness in controlling invasive species common to the Treasure Valley.

Methods

Trials were established at Alkali Springs north of Vale, Oregon to evaluate Plateau and Oasis for control of downy brome and medusahead rye. A trial was established just north of Ontario, Oregon to evaluate Plateau and Oasis for hoary cress control. At each location, herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were 10 ft wide and 30 ft long. Treatments were replicated three times in randomized complete block designs.

Medusahead Rye Control with Spring or Fall Applied Plateau and Oasis
Plateau and Oasis were evaluated for medusahead rye control when applied in the spring or in the fall. Medusahead rye was the predominant species in these trials with a small amount of downy brome throughout the studies. The treatments included Plateau

at 8 oz product/acre and Oasis at a range from 4 to 12 oz product/acre. These treatments were compared to Accord or Rodeo applied at 24 oz product/acre. Plateau and Oasis treatments also included methylated seed oil (MSO) at 1.0 qt/acre. Spring treatments were applied May 5, 2000 to medusahead that averaged 6 inches tall and downy brome that averaged 9 inches tall. Fall treatments were applied on November 11, 2000, to 2-inch-tall medusahead and 2-inch-tall downy brome.

Downy Brome Control with Fall-applied Plateau and Oasis
In this trial, downy brome was the predominant species with very little medusahead present. The objectives of the trial were to evaluate Plateau and Oasis for downy brome control as well as for safety to desirable species seeded at the time of treatment. Desirable species were planted with a 5-ft range drill just prior to herbicide application. Three different grass species and a grass and broadleaf mixture were seeded perpendicular to the herbicide plots and randomized to produce a split-plot design. The species planted included 'Hycrest' crested wheatgrass, 'Secar' Snake River wheatgrass, 'Goldar' bluebunch wheatgrass, and a mixture of grasses and western yarrow. One pass within each replication was left unseedded. The herbicide treatments included Plateau at 8 oz product/acre and Oasis at 4-12 oz product/acre. Plateau and Oasis treatments included MSO at 1.0 qt/acre. These treatments were compared to Escort at 1.0 oz product/acre applied with a non-ionic surfactant (NIS) at 0.25 percent v/v. Planting and herbicide application were completed on November 11, 2000. At the time of treatment, downy brome was approximately 2 inches tall.

Hoary Cress (Whitetop) Control with Plateau and Oasis
Plateau and Oasis were each applied at 4, 8, or 12 oz product/acre with MSO at 1.0 qt/acre. Treatments were compared to Escort at 1.0 oz/acre applied with NIS at 0.25 percent v/v. Escort is considered very effective for hoary cress control. Treatments were applied on May 12, 2000. At the time of application the hoary cress averaged 19 inches tall and was in the late bud to early flower growth stage. Hoary cress control was evaluated in the spring and summer of 2001 and the spring of 2002.

Results and Discussion

Medusahead Rye Control with Spring or Fall-applied Plateau and Oasis
On June 15, medusahead control with spring herbicide applications was similar between Accord, Plateau, and for Oasis at 8.0 oz /acre or above (Table 1). Downy brome control was greater with Accord than with Plateau or Oasis. Evaluations in March showed that Accord did not provide residual control of medusahead. Medusahaead control was similar for Plateau and Oasis at a rate of 8.0 oz/acre or above. In May, because of dry conditions, very little medusahead was growing in any of the Plateau or Oasis plots. In plots where the medusahead growth was suppressed by Accord the previous spring, downy brome was able to become the predominant species.

When treatments were applied in the fall, medusahead control was similar for all Plateau and Oasis treatments (Table 2). Rodeo plus NIS provided less control of both medusahead and downy brome compared to all other herbicide treatments. On May 25, the untreated plot had almost no downy brome growing in it because the medusahead had used the available water.

Downy Brome Control with Fall-applied Plateau and Oasis

Downy brome control on March 29, 2001 was greater than 93 percent for all Plateau or Oasis treatments (Table 3). Escort plus NIS provided little control. By May 24, downy brome control was slightly less with 4.0 oz rates compared with the 8.0 oz rates of both Plateau and Oasis. Because of the extremely dry winter none of the seeded grasses emerged and tolerance of these grasses to the herbicide treatments was not evaluated.

Hoary Cress (Whitetop) Control with Plateau and Oasis

Hoary cress control 1 year after treatment was greater than 89 percent for Escort or Plateau and Oasis each applied at 8 or 12 oz/acre (Table 4). Plateau and Oasis at 4 oz/acre provided less control than the other treatments. Approximately two years after treatment, Oasis and Plateau at 12 oz/acre provided 70 and 74 percent hoary cress control. Applied at the 12 oz/acre rate, both products provided greater control than lower rates and also greater control than Escort.

Table 1. Medusahead and downy brome control with spring herbicide applications, Alkali Springs north of Vale, OR. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

		Weed control						
		Medusahead					Downy brome	
Treatment*	Product rate	6-15-00	7-7-00	11-3-00	3-29-01	5-25-01	6-15-00	5-25-01
	fl oz/acre	%						
Plateau + MSO	8.0 + 1.0 qt	93	58	96	73	95	80	90
Oasis + MSO	4.0 + 1.0 qt	68	68	85	45	92	73	77
Oasis + MSO	6.0 + 1.0 qt	82	82	90	57	95	83	88
Oasis + MSO	8.0 + 1.0 qt	92	88	97	83	95	82	90
Oasis + MSO	10.0 + 1.0 qt	93	88	97	82	95	83	93
Oasis + MSO	12.0 + 1.0 qt	92	88	95	87	95	75	93
Accord	24.0	98	100	65	27	57	98	0
Untreated		0	0	0	0	0	0	90†
LSD (0.05)		13	30	7	18	5	11	6

*MSO = methylated seed oil.

†Downy brome control attributed to medusahead rye competition.

Table 2. Medusahead and downy brome control with fall herbicide applications, Alkali Springs north of Vale, OR. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

		Weed control			
		Medusahead			Downy brome
Treatment*	Product rate	11-3-00	3-29-01	5-25-01	5-25-01
	fl oz/acre	%			
Plateau + MSO	8.0 + 1.0 qt	96	73	95	90
Oasis + MSO	4.0 + 1.0 qt	85	45	92	77
Oasis + MSO	6.0 + 1.0 qt	90	57	95	88
Oasis + MSO	8.0 + 1.0 qt	97	83	95	90
Oasis + MSO	10.0 + 1.0 qt	97	82	95	93
Oasis + MSO	12.0 + 1.0 qt	95	87	95	93
Rodeo + NIS	24.0 + 0.25% v/v	65	27	57	0
Untreated		0	0	0	90†
LSD (0.05)		7	18	5	6

*MSO = methylated seed oil; NIS = non-ionic surfactant.

†Downy brome control attributed to medusahead rye competition.

Table 3. Downy brome control with fall herbicide applications, Alkali Springs north of Vale, OR; Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment*	Product rate	Downy brome control	
		March 29, 2001	May 24, 2001
	fl oz/acre	%	
Oasis + MSO	4.0 + 1.0 qt	93	95
Oasis + MSO	8.0 + 1.0 qt	98	97
Oasis + MSO	12.0 + 1.0 qt	98	98
Plateau + MSO	4.0 + 1.0 qt	95	93
Plateau + MSO	8.0 + 1.0 qt	98	98
Plateau + MSO	12.0 + 1.0 qt	98	98
Escort + NIS	1.0 + 0.25% v/v	7	0
Untreated		0	0
LSD (0.05)		8	2

*MSO = methylated seed oil; NIS = non-ionic surfactant.

Table 4. Hoary cress control with fall herbicide applications, Malheur River north of Ontario, OR. Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment*	Product rate	Hoary cress control	
		May 14, 2001	April 24, 2002
	fl oz/acre	%	
Oasis + MSO	4.0 + 1.0 qt	61	13
Oasis + MSO	8.0 + 1.0 qt	89	37
Oasis + MSO	12.0 + 1.0 qt	95	70
Plateau + MSO	4.0 + 1.0 qt	55	10
Plateau + MSO	8.0 + 1.0 qt	89	48
Plateau + MSO	12.0 + 1.0 qt	97	74
Escort + NIS	1.0 + 0.25% v/v	87	33
Untreated		0	0
LSD (0.05)		18	25

*MSO= methylated seed oil; NIS = non-ionic surfactant.

SUGAR BEET VARIETY TESTING RESULTS

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Introduction

The sugar beet industry, in cooperation with Oregon State University and the University of Idaho, tests sugar beet varieties at three replicate locations each year to identify cultivars with high sugar yield and root quality. A seed advisory committee evaluates the combined data to decide which varieties can be grown for contract sugar beet production. This report provides the agronomic practices, experimental procedures, and beet yields and quality for the Malheur Experiment Station replicate of the 2001 trial.

Methods

Sugar beet varieties were entered by ACH Seeds, Betaseed, Hilleshog Mono Hy, Holly Hybrids-Spreckels, and Seedex in 2001. Twenty-two varieties were tested in the Commercial Trial, and 29 varieties were tested (including the commercial check varieties) in the Experimental Trial. All seed for the Commercial Trial was organized by Ron Roemer of the University of Idaho, as were most of the seed of varieties in the Experimental Trial. Sugar beets were grown in a field that had grown winter wheat the year before. The Owyhee silt loam received 50 lb/acre N plus 50 lb/acre P fall fertilizer, the field was then plowed, disked, groundhogged, and fall bedded on 22-inch rows.

The results of a soil test taken on March 30, 2001, showed 8 ppm nitrate-N and 3 ppm ammonium-N in the first ft of soil; 3 ppm nitrate-N and 3 ppm ammonium-N in the second ft; 15 ppm extractable phosphorus, 0.6 ppm exchangeable zinc, pH 7.4, and 1.4 percent organic matter. The beds were remade using a bed harrow and Nortron SC preplant herbicide was applied at 6 pints/acre and incorporated using a spiked-tooth bed harrow on March 30.

The Experimental Trial and the Commercial Trial were planted on April 3. Seeds were planted with a John Deere model 71 flexi-planter with double disc furrow openers equipped with cone seeders to uniformly distribute the seed at a seeding rate of 12 viable seeds/ft of row. Plots of each variety were four rows wide by 23 ft long, with 4-ft allies separating plots at their ends. Each entry was replicated eight times in a randomized complete block design. On April 6 the field was corrugated and Counter 20CR was applied in a band over the row at 8.6 lb/acre. Weed seedlings were controlled before sugar beet emergence with Roundup herbicide at 0.5 gal/acre applied on April 16. The sugar beet seedling emergence was very uniform, and the field was furrow irrigated the first time on April 26. Seedlings were thinned by hand to one plant every 7 inches in the row on May 9 through 11. The trials were sidedressed with 200 lb

N/acre, 45 lb SO_4/acre, 50 lb S/acre, 3 lb Mn/acre, 1 lb Zn/acre, and 1 lb B/acre and recultivated on May 14. Treflan was applied at 1.5 pint/acre on May 19, and the field was cultivated with sweeps, twice, in opposite directions, to incorporate the herbicide. The second irrigation was applied May 24. The field was sidedressed with Temik at 10 lb/acre on May 27 to control sugar beet root maggot, and recorrugated.The field was irrigated a third time on May 27, to move the insecticide with the wetting front into the sugar beet seedlings' root zone. The field was hand weeded on June 7, and a crew hoed the trials on June 15.

On June 23 Flowable Sulfur 6 was applied by aerial applicator at 4 qt/acre for control of powdery mildew. Sulfur dust was applied by aerial applicator at 60 lb/acre on July 1, and again on July 14. Laredo fungicide was applied by aerial applicator, tank-mixed with flowable sulfur, on July 27, and again on August 25. Irrigations were scheduled with Watermark (Irrometer Co. Inc., Riverside, CA) soil moisture sensors to maintain the soil water potential wetter than -70 centibar at 8-inch depth in the beet row. The last irrigation was on September 13.

Sugar beets were harvested from the Commercial Trial on October 11 and 12, and from the Experimental Trial on October 12. The foliage was flailed and the crowns were removed with rotating knives. All beets in the center two rows of each plot were dug with a two-row wheel-lifter harvester and weighed, and two samples of eight sugar beets were taken from each plot. Samples were delivered each day to the Amalgamated Sugar plant in Nyssa for laboratory analysis of percent sucrose (Sug), pulp nitrate concentration, and conductivity (Cond). The percent extraction (Ext) was calculated using the formula:

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

The weight of sugar beets from each plot was tared 5 percent to calculate beet yields, and sugar concentrations were "factored" by multiplying by 0.98 to account for respiration. The sugar, nitrate, and conductivity data were examined for extreme outliers (data values greater than two standard deviations from the mean), and extreme outliers, except for high sugar concentrations, were deleted from the analysis. Two plots with root yields too high were deleted from each trial. Variety differences in yield, sucrose content, conductivity, percent extraction, and estimated recoverable sugar were calculated using ANOVA. Sugar beet performance in both trials was compared to the check varieties ACH Seeds 'ACH Mustang', Betaseed 'Beta 8757', and Hilleshog Mono Hy 'HM Owyhee' and 'HM PM21'.

Results

Stand establishment was very uniform in the 2001 sugar beet variety trials at Malheur Experiment Station. Prolonged hot weather in the summer promoted powdery mildew infection on sugar beet foliage in growers' fields in the vicinity. In the trials, powdery mildew was controlled by applications of liquid sulfur, sulfur dust, and Laredo fungicide.

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 46.1 tared ton/acre, average sugar content was 17.54 percent, and average estimated recoverable sugar was 13,942 lb/acre. 'ACH Tomcat', with estimated recoverable sugar 15,871 lb/acre; 'ACH Mustang', with estimated recoverable sugar 15,308 lb/acre; 'Beta 8220B', with estimated recoverable sugar 15,794 lb/acre; 'HM Owyhee', with estimated recoverable sugar 14,968 lb/acre; 'HM Oasis', with estimated recoverable sugar 14,494 lb/acre; 'Puma', with estimated recoverable sugar 14,853 lb/acre; and 'Cascade', with estimated recoverable sugar 14,397 lb/acre were among the highest yielding varieties in the Commercial Trial.

Root yield in the Experimental Trial (Table 2) averaged 46.7 tared ton/acre, with average sugar content 17.50 percent, and average estimated recoverable sugar 14,161 lb/acre. The varieties yielding the highest estimated recoverable sugar were 'Crystal 0003' with 14,357 lb/acre, 'Beta 7CG5936' with 15,567 lb/acre, 'Beta 7CG6000' with 15,455 lb/acre, 'Beta 8KG6976' with 15,059 lb/acre, 'Beta 8CG7299' with 14,985 lb/acre, 'HM Owyhee' with 14,851 lb/acre, 'HM 2983Rz' with 14,324 lb/acre, 'HM PM21' with 14,322 lb/acre, '00HX32' with 15,083 lb/acre, '01HX004 RZM' with 14,632 lb/acre, '01HX029' with 14,360 lb/acre, 'SX 1516' with 14,887 lb/acre, and 'SX1517' with 14,764 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, 2001.

	Root yield	Sugar content	Gross sugar	Conductivity	Extraction	Estimated recoverable sugar	
Variety	ton/acre	%	lb/acre	mmho	%	lb/ton	lb/acre
ACH Seeds							
ACH Tomcat	47.61	17.42	16,577	0.674	86.07	299.8	14,269
ACH Mustang	45.90	17.51	16,070	0.663	86.22	302.0	13,855
Crystal 9906	43.76	17.77	15,543	0.638	86.60	307.8	13,460
Betaseed							
Beta 8220B	53.45	17.16	18,328	0.661	86.18	295.7	15,794
Beta 8757	45.73	17.65	16,121	0.677	86.07	303.9	13,875
Beta 8919	44.01	18.05	15,898	0.654	86.44	312.1	13,749
Beta 4035R	46.37	17.22	15,968	0.694	85.77	295.4	13,696
Beta 8118	45.11	17.63	15,904	0.691	85.88	302.8	13,654
Beta 4490R	46.28	17.11	15,834	0.715	85.48	292.6	13,533
Beta 8348	43.67	17.28	15,079	0.706	85.62	295.9	12,911
Beta 4546	43.12	17.39	14,993	0.721	85.45	297.3	12,814
Beta 4470R	37.14	17.72	13,166	0.709	85.66	303.6	11,278
Hilleshog Mono Hy							
HM Owyhee	49.01	17.63	17,257	0.624	86.75	305.8	14,968
HM Oasis	47.87	17.43	16,688	0.612	86.87	302.9	14,494
HM 1642	45.48	18.11	16,469	0.607	87.06	315.4	14,336
HM 2980Rz	48.00	17.25	16,553	0.700	85.70	295.7	14,186
HM PM21	43.98	17.61	15,489	0.622	86.78	305.6	13,439
Holly Hybrids-Spreckels							
HH 120	46.68	17.57	16,407	0.714	85.57	300.7	14,042
HH 125	41.83	18.05	15,101	0.581	87.39	315.5	13,198
Seedex							
Puma	49.07	17.42	17,089	0.609	86.91	302.7	14,853
Cascade	47.20	17.52	16,527	0.595	87.11	305.3	14,397
Blazer	42.78	17.42	14,911	0.662	86.22	300.4	12,863
Mean	45.64	17.54	15999	0.660	86.26	302.7	13803
LSD (0.05)	2.75	0.37	942	0.049	0.66	7.8	819

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, 2001.

Variety	Root yield ton/acre	Sugar content %	Gross sugar lb/acre	Conductivity mmho	Extraction %	Estimated recoverable sugar lb/ton	Estimated recoverable sugar lb/acre
ACH Seeds							
Crystal 0003	46.25	17.87	16,526	0.62	86.87	310.5	14,357
ACH Mustang	47.44	17.30	16,418	0.66	86.26	298.5	14,163
Crystal 0002	47.06	17.32	16,305	0.67	86.07	298.2	14,034
Crystal 9908	43.33	17.55	15,210	0.68	86.02	302.0	13,084
Crystal C111	43.52	17.24	15,008	0.67	86.14	297.0	12,930
Betaseed							
Beta 7CG5936	50.42	17.67	17,809	0.57	87.41	308.8	15,567
Beta 7CG6000	51.77	17.23	17,830	0.62	86.68	298.8	15,455
Beta 8KG6976	48.92	17.68	17,295	0.60	87.07	307.9	15,059
Beta 7KJ5073	45.21	17.63	15,939	0.66	86.36	304.6	13,765
Beta 8CG7299	44.50	17.83	15,860	0.69	85.91	306.3	13,624
Beta 1YK0012	43.21	18.01	15,569	0.60	87.13	313.9	13,568
Beta 8757	45.42	17.33	15,734	0.69	85.82	297.4	13,502
Beta 1YK0013	43.21	17.69	15,280	0.62	86.78	307.0	13,260
Beta 1YK0011	40.14	18.21	14,616	0.65	86.54	315.2	12,651
Hilleshog Mono Hy							
HM Owyhee	48.21	17.65	17,015	0.58	87.29	308.2	14,851
HM 2983Rz	47.84	17.26	16,494	0.61	86.86	299.8	14,324
HM PM21	47.11	17.44	16,420	0.58	87.24	304.3	14,322
HM 2984Rz	46.62	17.43	16,251	0.61	86.94	303.0	14,134
Holly Hybrids-Spreckels							
01HX004 RZM	50.57	16.46	16,726	0.69	86.82	285.8	14,532
01HX029	48.30	17.14	16,536	0.61	86.85	297.8	14,360
Phoenix RZM	49.13	16.86	16,548	0.68	85.94	289.8	14,224
00HX035 RZM	43.73	18.19	15,906	0.53	88.00	320.2	13,998
00HX011 RZM	45.42	17.41	15,893	0.53	87.95	306.1	13,976
00HX33	44.62	17.72	15,800	0.58	87.40	309.8	13,809
00HX32	47.20	16.99	16,033	0.70	85.70	291.2	13,737
01HX047	41.19	17.97	14,787	0.63	86.75	311.7	12,826
Seedex							
SX1516	48.73	17.43	16,980	0.55	87.69	305.6	14,887
SX1517	50.23	17.17	17,250	0.71	85.58	293.9	14,764
SX1518	44.90	17.95	16,132	0.62	86.81	311.7	14,006
Mean	46.35	17.50	16,213	0.63	86.72	303.6	14,061
LSD (0.05)	2.66	0.34	928	0.03	0.71	7.1	826

TRANSGENIC SUGAR BEET VARIETY TESTING RESULTS

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Introduction

Transgenic sugar beet varieties were compared to standard commercial sugar beet varieties for root yield, sugar content, and extractable sugar. The transgenic sugar beet varieties that were tested have genes that confer resistance to the non-selective herbicides Liberty and Roundup.

Methods

Four commercial varieties and seven transgenic varieties were evaluated for yield and sugar content in a trial conducted at the Malheur Experiment Station, Ontario, Oregon. The commercial varieties were American Crystal 'ACH Mustang', Betaseed '8757', and Hilleshog Mono-Hy 'PM 21' and 'Owyhee'. The only Liberty-resistant variety was Betaseed '8757 Liberty Link' (LL). The Roundup resistant-varieties were Hilleshog Mono-Hy 'HM 108 Roundup Ready' (RR), 'HM Oasis RR', 'HM 125 Rz RR', Betaseed '8757 RR', '7CG9236 RR', and American Crystal '9931 RR'.

Varieties were planted in four-row plots 23 ft long with 4-ft alleys between plots. Rows were 22 inches wide. Each strip of 4-row plots was separated from adjacent plots by an unplanted row. The unplanted row served as a buffer to reduce the possibility of injuring nonresistant beets while applying Roundup and Liberty herbicides to adjacent plots of resistant sugar beet varieties. Each entry was replicated eight times in a randomized complete block experimental design. Sugar beet varieties were planted on April 12 using a cone-seeder mounted on a John Deere model 71 Flexi-planter. 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.

On May 14, sugar beet stands were thinned to one plant for every 7 inches of row. The beets were sidedressed with 250 lb/acre of N as urea on May 23. Because initial herbicide treatments were not made prior to thinning, and one of the herbicide-resistant varieties was reported to have a high percentage of nonresistant plants, herbicides were not sprayed on any of the varieties to prevent reducing the sugarbeet stand. Weeds were controlled throughout the season by hand weeding.

On May 24, Temik 15G (10 lb/acre) was applied for sugar beet root maggot control. For powdery mildew control, Super Six liquid sulfur (1 gal/acre) was applied on June 23, sulfur dust (60 lb/acre) was applied July 1 and July 14, and Laredo fungicide combined with liquid sulfur was applied on July 27 and August 25. All fungicide treatments were applied by air.

Sugar beets were harvested on October 4. The foliage was removed with a flail beater and the crowns were clipped with rotating scalping knives. Roots were harvested from the center two rows of each plot using a two-row, wheel-type lifter-harvester. The total sugar beet weight from each plot was used to calculate root yield. Root yields were adjusted for a 5 percent tare. Two samples of eight beets each were 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 sugar content and purity. The percent sugar extraction and recoverable sugar were estimated using empirical equations.

Data were analyzed using ANOVA, and variety means were separated using a protected least significant difference at the 5 percent level, LSD (0.05).

Results

Some stand loss occurred as a result of sugar beet root maggot feeding. Power lines adjacent to the trial area made aerial application difficult, resulting in heavier powdery mildew pressure in parts of the trial closest to the power lines. No bolting plants were observed for any of the varieties in the trial. 'ACH 9931 RR' had reduced stand (36,157 plants/acre) compared to all other varieties (38,540 to 40,444 plants/acre). This seemed to correlate with curly top injury that was observed during visual evaluations.

The average root yield for this trial was 42.15 ton/acre, which was slightly lower than in 2000. The average percent sugar was 16.95 percent, which was higher than in 2000 and closer to that recorded in 1999. Beet yields ranged from 43.79 tons/acre for 'HM PM 21' to 39.92 ton/acre for 'ACH 9931 RR'. 'Beta 8757 LL', 'ACH 9931 RR', 'HM PM 21' and 'HM Oasis RR' were among the highest in percent sugar, while 'HM 108 RR' and 'HM 125 Rz RR' were among the lowest in percent sugar. 'HM PM 21', 'HM Owyhee', and 'HM Oasis RR' had the highest percent extraction (92.81 to 93.06 percent). 'Beta 8757 LL', 'HM Owyhee', and 'HM PM 21' were among the highest in recoverable sugar per ton of beets and per acre. 'ACH 9931 RR' and 'HM Oasis RR' also had some of the highest sugar per ton of beets but produced less sugar per acre than some of the highest producing beets because of lower root yields.

Because no herbicides were applied, this trial provides an opportunity to compare the yield potential of the varieties tested without the confounding affects of herbicide injury. When herbicides are applied we would expect the herbicide-resistant varieties to have less injury than varieties treated with conventional herbicides.

Table 1. Root yields, sugar yields, and root quality data from sugar beet varieties in the transgenic variety trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Variety	Root yield	Sugar content	Gross sugar	Extraction	Estimated recoverable sugar	
	ton/acre	%	lb/acre	%	lb/ton	lb/acre
American Crystal						
ACH Mustang	41.92	16.83	14,104	92.08	309.9	12,987
ACH 9931 RR	39.92	17.26	13,782	92.37	318.9	12,730
Betaseed						
Beta 8757 LL	42.68	17.20	14,674	92.43	317.9	13,563
Beta 8757 RR	42.62	17.03	14,512	92.01	313.3	13,352
Beta 8757	41.89	16.91	14,168	92.10	311.6	13,051
Beta 7CG9236 RR	41.67	16.98	14,149	92.02	312.5	13,020
Hilleshog Mono-Hy						
HM PM 21	43.79	17.14	15,010	93.06	319.1	13,968
HM Owyhee	43.36	16.95	14,703	92.89	315.02	13,658
HM 108 RR	42.93	16.61	14,263	92.03	305.7	13,129
HM Oasis RR	40.84	17.09	13,965	92.81	317.3	12,961
HM 125 Rz RR	42.07	16.43	13,827	92.39	303.6	12,775
Mean	42.15	16.95	14,287	92.38	313.2	13,199
LSD (0.05)	1.84	0.23	615	0.39	4.9	578

KOCHIA CONTROL WITH VARIABLE NORTRON® RATES IN STANDARD AND MICRO-RATE HERBICIDES PROGRAMS

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Introduction

The distribution of kochia resistant to acetolactate synthase (ALS) inhibitors (i.e., sulfonyl ureas, imidazolinones) 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 was evaluated for postemergence control of ALS-resistant kochia in sugar beets. Nortron is a soil-active herbicide used preemergence or early postemergence to control annual grasses and broadleaf weeds.

Methods

Trials were established at the Malheur Experiment Station under furrow irrigation on April 12, 2001. Sugar beets (Hilleshog 'WS PM-21') were planted in 22-inch rows at a 2-inch seed spacing. Sugar beets were thinned to 8-inch spacings on May 16. Plots were sidedressed on May 23 with 200 lbs N/acre as urea. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots four rows wide and 27 ft long were arranged in a randomized complete block design. Roundup (0.75 lb ai/acre) was applied preemergence to all trials. 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 2.

On April 11, kochia seed was spread over the entire experimental area to provide an even weed distribution. UpBeet was omitted from selected treatments to simulate ALS resistance and to better evaluate Nortron efficacy on kochia. Nortron was applied postemergence in various tank-mix combinations at 0.063, 0.125, 0.04, and 0.027 lb ai/acre to sugar beets ranging from cotyledon up to the eight-leaf stage. Standard rate tank-mix combinations with Nortron included Progress (0.25, and 0.33 lb ai/acre), UpBeet (0.016 lb ai/acre), and Stinger (0.098 lb ai/acre) applied three times at 7- to 10-day intervals. Micro-rate treatments consisted of various combinations of Progress (0.08 lb ai/acre), Betamix (0.053 and 0.08 lb ai/acre), UpBeet (0.005 lb ai/acre), Stinger (0.031 lb ai/acre), and methylated seed oil (MSO) (1.5 percent v/v), with and without Nortron, applied a total of four times at 7-day intervals. Weed control and injury were evaluated periodically throughout the growing season. In addition to sugar beet root yield, 16 sugar beets from each plot were sent to the Hilleshog Mono-Hy Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity.

Results and Discussion

On June 25, common lambsquarters control was excellent (97 to 100 percent) with all treatments (Table 1). Redroot pigweed control was greater with the micro-rate when Stinger was included in the tank-mix. Redroot pigweed control on August 22 was generally greater for those treatments containing UpBeet except for the micro-rate when Stinger was not included in the tank-mix. Hairy nightshade control ranged from 83 to 100 percent on June 25. On August 22, hairy nightshade control was generally good to excellent (82 to 98 percent) with all treatments except those not containing Stinger. On both June 25 and August 22, kochia control was significantly greater with treatments including UpBeet than without regardless of UpBeet rate or whether the treatment was applied as a standard or micro-rate. Treatments with Nortron applied postemergence without UpBeet provided poor (34 to 66 percent) kochia control on June 25. The addition of Nortron at both 0.063 and 0.125 lb ai/acre to the micro-rate treatment of Progress (0.08 lb ai/acre), UpBeet (0.005 lb ai/acre), Stinger (0.031 lb ai/acre), and MSO significantly increased kochia control evaluated on August 22 (Table 1). For all other treatments the addition of Nortron did not increase kochia control.

Sugar beet injury from standard rate treatments where Progress (0.25 or 0.33 lb ai/acre) and UpBeet (0.016 lb ai/acre) were applied together produced injury ranging from 35 to 42 percent on May 12 (Table 2). Generally, injury from these treatments remained higher than other treatments on May 24 and June 4. Visual injury was not significant for any treatment on June 25 (data not shown). Sugar beet injury was greater on May 24 and June 4, when Nortron (0.053 lb ai/acre) was applied in applications 1 and 2, and when Nortron (0.04 lb ai/acre) in applications 3 and 4 was added to Betamix (0.08 lb ai/acre) plus UpBeet (0.005 lb ai/acre) plus Stinger (0.031 lb ai/acre) and MSO.

Sugar beet root yields were different among treatments and were generally related to weed control. Root and estimated recoverable sucrose (ERS) yields were significantly higher with treatments containing UpBeet (Table 2). There was a positive correlation between ERS yields and kochia control (Fig. 1). Nortron applied postemergence did not increase root or extractable sucrose yields for any treatment. In general percent sucrose and percent extraction were similar among treatments ranging from 15.19 to 16.93 percent and 92.63 to 93.46 percent, respectively (Table 2).

Table 1. Weed control with standard and micro-rate treatments with and without various Nortron rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Weed control						
			Pigweed		H. nightshade		Kochia		Lambsquarters
Treatment	Rate	Timing*	6-25	8-22	6-25	8-22	6-25	8-22	6-25
	lb ai/acre % v/v		%						
Untreated	--	--	0	0	0	0	0	0	0
Progress + UpBeet Progress + UpBeet + Stinger	0.25 + 0.016 0.33 + 0.016 + 0.098	1 2, 3	98	85	98	95	93	84	100
Progress Progress + Stinger	0.25 0.33 + 0.098	1 2, 3	76	40	89	39	34	13	100
Progress + UpBeet + Stinger + MSO	0.08 + 0.005 + 0.031 + 1.5%	1,2,3,4	95	89	98	92	87	69	100
Progress + UpBeet + Stinger + Nortron + MSO	0.08 + 0.005 + 0.031 + 0.063 + 1.5%	1,2,3,4	95	89	100	91	94	91	100
Progress + UpBeet + Stinger + Nortron + MSO	0.08 + 0.005 + 0.031 + 0.125 + 1.5%	1,2,3,4	89	76	99	94	95	92	97
Progress Progress	0.25 0.33	1 2,3	82	0	93	0	36	0	100
Progress + Nortron Progress + Nortron	0.25 + 0.063 0.33 + 0.063	1 2,3	92	82	85	85	47	18	100
Progress + Nortron Progress + Nortron Progress	0.25 + 0.125 0.33 + 0.125 0.33	1 2 3	85	45	96	--	37	7	100
Progress + UpBeet Progress + UpBeet	0.25 + 0.016 0.33 + 0.016	1 2,3	92	77	83	62	97	93	98
Progress + UpBeet + Nortron Progress + UpBeet + Nortron	0.25 + 0.016 + 0.063 0.33 + 0.016 + 0.063	1 2,3	93	83	96	87	95	89	100
Progress + UpBeet + Nortron Progress + UpBeet + Nortron Progress + UpBeet	0.25 + 0.016 + 0.125 0.33 + 0.016 + 0.125 0.33 + 0.016	1 2 3	98	93	98	95	97	91	100
Progress + UpBeet + MSO	0.08 + 0.005 + 1.5%	1,2,3,4	80	57	91	53	96	88	100
Progress + UpBeet + Nortron + MSO	0.08 + 0.005 + 0.063 + 1.5%	1,2,3,4	79	63	87	60	92	84	100
Progress + UpBeet + MSO Nortron	0.08 + 0.005 + 1.5% 0.125	1,2,3,4 1,2	85	53	95	50	92	89	100
Progress + UpBeet + MSO Nortron Nortron	0.08 + 0.005 + 1.5% 0.063 0.125	1,2,3,4 1,2 3	86	66	92	82	91	78	100

Table 1 *(continued).* Weed control with standard and micro-rate treatments with and without various Nortron rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Weed control						
			Pigweed		H. nightshade		Kochia		Lambsquarters
Treatment	Rate	Timing*	6-25	8-22	6-25	8-22	6-25	8-22	6-25
	lb ai/acre % v/v		---------------------------------------%---------------------------------------						
Progress + Nortron	0.25 + 0.063	1	69	53	83	55	66	20	100
Progress + Nortron	0.33 + 0.063	2							
Progress + Nortron	0.33 + 0.125	3							
Betamix + UpBeet + Stinger + MSO	0.08 + 0.005 + 0.031 + 1.5%	1,2,3,4	88	72	100	83	95	88	100
Betamix + Nortron + Upbeet + Stinger + MSO	0.053 + 0.027 + 0.005 + 0.031 + 1.5%	1,2	96	85	100	98	97	95	100
Betamix + Nortron + Upbeet + Stinger + MSO	0.08 + 0.04 + 0.005 + 0.031 + 1.5%	3,4							
Betamix + Nortron + Upbeet + Stinger + MSO	0.08 + 0.04 + 0.005 + 0.031 + 1.5%	1,2	99	81	100	92	94	93	100
Betamix + Nortron + Upbeet + Stinger + MSO	0.12 + 0.04 + 0.005 + 0.031 + 1.5%	3,4							
Betamix + Nortron + Upbeet + Stinger + MSO	0.08 + 0.04 + 0.005 + 0.031 + 1.5%	1,2	98	78	100	86	97	94	100
Betamix + Nortron + Upbeet + Stinger + MSO	0.12 + 0.081 + 0.005 + 0.031 + 1.5%	3,4							
Betamix + Nortron + Upbeet + Stinger + MSO	0.08 + 0.04 + 0.005 + 0.031 + 1.5%	1	99	76	97	95	94	86	99
Betamix + Nortron + Upbeet + Stinger + MSO	0.08 + 0.081 + 0.005 + 0.031 + 1.5%	2							
Betamix + Nortron + Upbeet + Stinger + MSO	0.12 + 0.081 + 0.005 + 0.031 + 1.5%	3							
Betamix + Upbeet + Stinger + MSO	0.12 + 0.005 + 0.031 + 1.5%	4							
Betamix + Nortron + UpBeet + Stinger + MSO	0.08 + 0.081 + 0.005 + 0.031 + 1.5%	1	96	78	100	98	94	92	100
Betamix + Nortron + UpBeet + Stinger + MSO	0.12 + 0.12 + 0.005 + 0.031 + 1.5%	2							
Betamix + UpBeet + Stinger + MSO	0.12 + 0.005 + 0.031 + 1.5%	3							
Hand-weeded	--	--	73	63	94	87	87	67	98
LSD (0.05)			13.8	25	13	28	13	19	2

*Application timings were (1) April 26 to cotyledon sugar beets, (2) May 3 to two-leaf sugar beets, (3) May 8 to four-leaf sugar beets, and (4) May 17 to eight-leaf sugar beet.

Table 2. Sugar beet injury and yield with standard and micro-rate treatments with and without various Nortron rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Injury			Sugar beet yield			
Treatment	Rate	Timing*	5-12	5-24	6-4	Root yield	Sucrose	Extraction	ERS†
	lb ai/acre % v/v		------------ % ------------			ton/acre	-----------%----------		lb/acre
Untreated	--	--	0	0	0	8.7	16.81	93.23	2,706
Progress + UpBeet Progress + UpBeet + Stinger	0.25 + 0.016 0.33 + 0.016 + 0.098	1 2, 3	42	45	27	40.4	16.37	93.45	12,363
Progress Progress + Stinger	0.25 0.33 + 0.098	1 2, 3	15	18	6	21.9	16.93	93.15	6,862
Progress + UpBeet + Stinger + MSO	0.08 + 0.005 + 0.031 + 1.5%	1,2,3,4	17	17	12	41.6	16.59	93.16	12,849
Progress + UpBeet + Stinger + Nortron + MSO	0.08 + 0.005 + 0.031 + 0.063 + 1.5%	1,2,3,4	22	22	8	42.7	15.19	92.65	11,962
Progress + UpBeet + Stinger + Nortron + MSO	0.08 + 0.005 + 0.031 + 0.125 + 1.5%	1,2,3,4	22	19	14	42.4	16.38	93.02	12,936
Progress Progress	0.25 0.33	1 2,3	28	25	15	22.6	16.19	93.15	6,888
Progress + Nortron Progress + Nortron	0.25 + 0.063 0.33 + 0.063	1 2,3	20	21	9	24.5	16.80	92.96	7,676
Progress + Nortron Progress + Nortron Progress	0.25 + 0.125 0.33 + 0.125 0.33	1 2 3	23	24	18	22.9	16.26	93.24	6,982
Progress + UpBeet Progress + UpBeet	0.25 + 0.016 0.33 + 0.016	1 2,3	35	40	29	40.0	16.59	93.33	12,372
Progress + UpBeet + Nortron Progress + UpBeet + Nortron	0.25 + 0.016 + 0.063 0.33 + 0.016 + 0.063	1 2,3	42	44	31	40.8	16.49	93.11	12,517
Progress + UpBeet + Nortron Progress + UpBeet + Nortron Progress + UpBeet	0.25 + 0.016 + 0.125 0.33 + 0.016 + 0.125 0.33 + 0.016	1 2 3	40	41	27	41.3	16.39	93.03	12,613
Progress + UpBeet + MSO	0.08 + 0.005 + 1.5%	1,2,3,4	19	12	11	38.0	16.27	93.11	11,534
Progress + UpBeet + Nortron + MSO	0.08 + 0.005 + 0.063 + 1.5%	1,2,3,4	14	17	21	38.9	16.62	93.34	12,082
Progress + UpBeet + MSO Nortron	0.08 + 0.005+ 1.5% 0.125	1,2,3,4 1,2	23	15	11	40.3	16.07	93.20	12,067
Progress + UpBeet + MSO Nortron Nortron	0.08 + 0.005+ 1.5% 0.063 0.125	1,2,3,4 1,2 3	15	17	12	42.0	16.13	92.92	12,612

Table 2 *(continued)*. Sugar beet injury and yield with standard and micro-rate treatments with and without various Nortron rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	Timing*	Injury 5-12	Injury 5-24	Injury 6-4	Root yield	Sugar beet yield Sucrose	Sugar beet yield Extraction	Sugar beet yield ERS[†]
	lb ai/acre % v/v		------------ %	------------		ton/acre	-----------%----------		lb/acre
Progress + Nortron	0.25 + 0.063	1	22	28	22	23.8	16.39	93.46	7,289
Progress + Nortron	0.33 + 0.063	2							
Progress + Nortron	0.33 + 0.0125	3							
Betamix + UpBeet + Stinger + MSO	0.08 + 0.005 + 0.031 + 1.5%	1,2,3,4	18	22	7	41.2	15.56	92.63	11,922
Betamix + Nortron + Upbeet + Stinger + MSO	0.053 + 0.027 + 0.005 + 0.031 + 1.5%	1,2	19	32	21	41.3	15.45	92.91	11,888
Betamix + Nortron + Upbeet + Stinger + MSO	0.08 + 0.04 + 0.005 + 0.031 + 1.5%	3,4							
Betamix + Nortron + Upbeet + Stinger + MSO	0.08 + 0.04 + 0.005 + 0.031 + 1.5%	1,2	21	19	6	44.8	16.04	93.13	13,364
Betamix + Nortron + Upbeet + Stinger + MSO	0.12 + 0.04 + 0.005 + 0.031 + 1.5%	3,4							
Betamix + Nortron + Upbeet + Stinger + MSO	0.08 + 0.04 + 0.005 + 0.031 + 1.5%	1,2	19	15	16	46.0	15.86	93.01	13,520
Betamix + Nortron + Upbeet + Stinger + MSO	0.12 + 0.081 + 0.0053 + 0.031 + 1.5%	3,4							
Betamix + Nortron + Upbeet + Stinger + MSO	0.08 + 0.04 + 0.005 + 0.031 + 1.5%	1	15	26	15	40.3	16.24	93.24	12,212
Betamix + Nortron + Upbeet + Stinger + MSO	0.08 + 0.081 + 0.005 + 0.031 + 1.5%	2							
Betamix + Nortron + Upbeet + Stinger + MSO	0.12 + 0.081 + 0.005 + 0.031 + 1.5%	3							
Betamix + Upbeet + Stinger + MSO	0.12 + 0.005 + 0.031 + 1.5%	4							
Betamix + Nortron + UpBeet + Stinger + MSO	0.08 + 0.081 + 0.005 + 0.031 + 1.5%	1	20	25	15	39.5	16.84	92.99	12,366
Betamix + Nortron + UpBeet + Stinger + MSO	0.12 + 0.12 + 0.005 + 0.031 + 1.5%	2							
Betamix + UpBeet + Stinger + MSO	0.12 + 0.005 + 0.031 + 1.5%	3							
Hand weeded	--	--	0	3	5	39.3	16.11	93.07	11,907
LSD (0.05)			11.4	10	12	6.2	1.41	0.68	2,201

*Application timings were (1) April 26 to cotyledon sugar beets, (2) May 3 to two-leaf sugar beets, (3) May 8 to four-leaf sugar beets and (4) May 17 to eight-leaf sugar beets.

[†]Estimated recoverable sucrose.

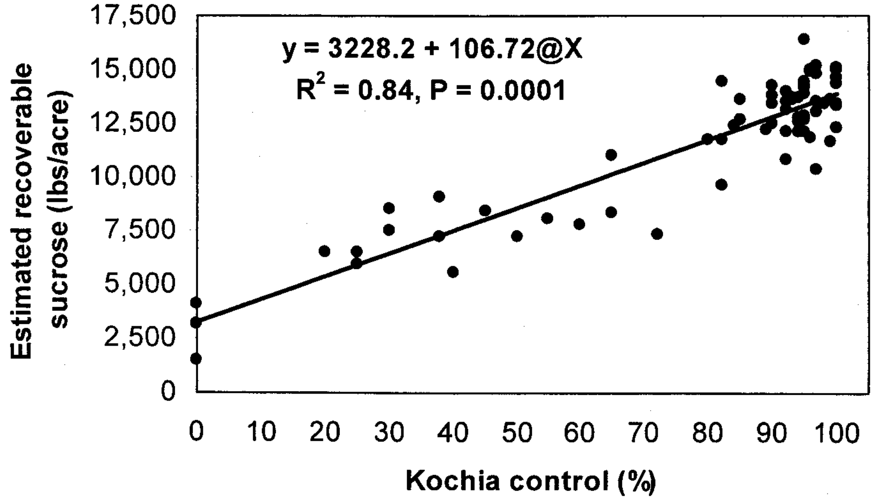

Figure 1. Response of sugar beet estimated recoverable sucrose yields to percent kochia control.

MICRO-RATE HERBICIDE PROGRAMS FOR WEED CONTROL IN SUGAR BEETS

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Introduction

Many growers are adapting the use of micro-rate herbicides for weed control in sugar beets. Research has shown that sugar beet herbicides can be applied as a broadcast treatment at the band application rate if a methylated seed oil (MSO) surfactant is added. In order for these extremely low-rate treatments to be effective they must be applied while weeds are small and treatments are applied four or more times on a 5- to 7-day interval. Trials were initiated to examine micro-rate herbicide treatments for weed control efficacy and sugar beet tolerance. One trial compared four applications of the micro-rate with three applications of the micro-rate alone or in combination with Dual Magnum, Nortron, or Outlook. All micro-rate treatments were compared to a standard herbicide program. The second trial compared micro-rate treatments containing different grass herbicides and/or the addition of Outlook for weed control efficacy.

Methods

General

Trials were established at the Malheur Experiment Station under furrow irrigation on April 12, 2001. Sugar beets (Hilleshog 'WS PM-21') were planted in 22-inch rows at a 2-inch seed spacing. 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 spacings on May 16. Plots were sidedressed on May 23 with 200 lb N/acre as urea. All plots were treated with Roundup (0.75 lb ai/acre) prior to sugar beet emergence. On May 24, Temik 15G (10 lb/acre) was applied for sugar beet root maggot control. For powdery mildew control, Super Six liquid sulfur (1 gal/acre) was applied on June 23, sulfur dust (60 lb/acre) was applied July 1 and July 14, and Laredo fungicide combined with liquid sulfur was applied on July 27 and August 25. All fungicide treatments were applied by air.

Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots four rows wide and 27 ft long were arranged in a randomized complete block design with three replications. 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 2. Root yields were adjusted to account for a 5 percent tare.

Data were analyzed using analysis of variance and means were separated using protected LSD at the 95 percent confidence interval ($P = 0.05$).

Number of Applications and Additions of Soil-active Herbicides to the Micro-rate Herbicide Program

Micro-rate treatments were applied three or four times. In some of the treatments receiving only three applications, Dual Magnum, Nortron, or Outlook were applied in the last application to provide residual control of germinating weeds. All treatments were compared to the micro-rate applied four times and to standard and half-rate treatments that contained MSO, both applied three times. 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 MSO (1.5 percent v/v). Micro-rate treatments were applied on April 24, April 30, May 7, and May 12. The standard treatments were applied on April 24, May 4, and May 12. At the first application, sugar beets were in the cotyledon growth stage. At harvest, 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 sugar content and purity. The percent sugar extraction and recoverable sugar were estimated using empirical equations.

Micro-rate Treatments with Various Grass Herbicides and/or Outlook

Micro-rate treatments with the addition of different grass herbicides and/or Outlook were evaluated for broadleaf and grass control. Micro-rate treatments contained Progress (1.3 oz ai/acre), Upbeet (0.063 oz ai/acre), Stinger (0.5 oz ai/acre), and MSO (1.5 percent v/v). Poast was added to the micro-rate at 1.15 or 1.5 oz ai/acre alone and at 1.2 oz ai/acre with Outlook applied in the third application or split between the third and fourth applications. Outlook was also added to the third micro-rate application with no grass herbicide applied. Grass control was compared with Poast, Select (0.5 oz ai/acre), and Assure II (0.44 oz ai/acre). Treatments were applied on April 24, April 30, May 7, and May 12.

Results and Discussion

Number of Applications and Additions of Soil-active Herbicides to the Micro-rate Herbicide Program

Three applications of the micro-rate herbicide treatment resulted in less kochia control compared to four applications, while control was similar for the other species evaluated (Table 1). Three applications of the micro-rate with Outlook included in the last application improved redroot pigweed and late season kochia control compared to three micro-rate applications alone. Late season pigweed control with the micro-rate/Outlook combination was greater than with four applications of the micro-rate. The standard treatment provided among the greatest kochia control. All treatments caused early season sugar beet injury, but injury had decreased by June 25 (Table 2). Sugar beet root and sugar yields correlated with weed control. Adding Outlook to the third application of the micro-rate increased root yields and estimated recoverable sucrose compared to three applications alone and provided yields similar to four applications of the micro-rate.

Micro-rate Treatments with Various Grass Herbicides and/or Outlook

All treatments caused significant sugar beet injury early in the season (Table 3). Similar to other trials, injury decreased by June 25. Few differences in broadleaf weed control were apparent. However, late season barnyardgrass control was greatest with treatment containing both Poast and Outlook. Treatments where Outlook was applied without Poast provided greater late season barnyardgrass control than treatments containing Poast. Outlook alone provided less control of wild oats than all other treatments except Assure II. Select and Assure II also had greater late season barnyardgrass control than Poast at either rate. Treatments containing Poast and Outlook or Select had increased yields compared to the treatment containing Assure II.

Table 1. Weed control with micro-rate herbicide treatments applied a different number of times and in various combinations and a standard herbicide program, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Weed control						
			Redroot pigweed		Common lambsquarters	Hairy nightshade		Kochia	
Treatment	Rate	Timing*	6-25	8-23	6-25	6-25	8-23	6-25	8-23
	oz ai/acre		%						
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,2,4,5	82	59	93	92	79	89	79
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,2,4	73	54	89	85	69	83	64
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,2	92	83	95	93	89	87	78
Progress + Upbeet + Stinger + Select + MSO + Outlook	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 10.0	4							
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,2	84	73	91	92	81	93	79
Progress + Upbeet + Stinger + Select + MSO + Dual Magnum	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 21.0	4							
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,2	78	50	98	100	86	87	79
Progress + Upbeet + Stinger + Select + MSO + Nortron	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 16.0	4							
Progress + Upbeet + Stinger + MSO	2.0 + 0.125 + 0.75 + 1.5% v/v	1,3,5	62	43	92	93	79	96	90
Progress + Upbeet + Stinger	4.0 + 0.25 + 1.5	1,3,5	86	66	100	100	98	96	92
Untreated			0	0	0	0	0	0	0
LSD (0.05)			17	20	13	11	27	5	11

*Treatments were applied on April 24 (1), April 30 (2), May 4 (3), May 7 (4), and May 12 (5).

Table 2. Sugar beet injury and yield with micro-rate herbicide applications applied a different number of times and in various combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	Timing*	Injury 5-12	Injury 5-22	Injury 6-4	Injury 6-25	Sugar beet† Root yield	Sugar beet† Sugar	Sugar beet† 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	1,2,4,5	28	32	25	0	38.5	16.13	93.29	11,570
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,2,4	24	28	21	0	31.9	16.69	93.15	9,931
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,2	32	27	25	2	42.4	16.79	93.25	13,291
Progress + Upbeet + Stinger + Select + MSO + Outlook	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 10.0	4								
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,2	33	23	23	3	39.3	16.33	93.14	11,973
Progress + Upbeet + Stinger + Select + MSO + Dual Magnum	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 21.0	4								
Progress + Upbeet + Stinger + Select + MSO	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v	1,2	35	28	16	3	37	15.75	92.83	10,837
Progress + Upbeet + Stinger + Select + MSO + Nortron	1.3 + 0.063 + 0.5 + 0.5 + 1.5% v/v + 16.0	4								
Progress + Upbeet + Stinger + MSO	2.0 + 0.125 + 0.75 + 1.5% v/v	1,3,5	18	18	18	0	34.6	16.36	92.73	10,488
Progress + Upbeet + Stinger	4.0 + 0.25 + 1.5	1,3,5	35	18	25	0	37.1	16.23	92.79	11,182
Untreated			0	0	0	0	9.1	16.66	92.67	2,781
LSD (0.05)			10	20	11	NS	9.4	0.56	NS	2,909

*Treatments were applied on April 24 (1), April 30 (2), May 4 (3), May 7 (4), and May 12 (5).
†Sugar beets were harvested on October 3.
‡ Estimated recoverable sucrose.

Table 3. Sugar beet injury, weed control, and sugar beet yield with micro-rate herbicide applications with various grass herbicides and/or Outlook, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Injury		Weed control‡					Late	
Treatment*	Rate	Timing†	5-22	6-25	Redroot pigweed	Common lambsquarters	Hairy nightshade	Barnyard-grass	Wild oat	Barnyard-grass	Root yield§
	oz ai/acre		%								ton/acre
Poast	1.15	1,2,3,4	20	2	94	98	96	87	100	50	37.0
Poast	1.53	1,2,3,4	28	8	91	97	98	87	100	53	37.4
Poast Outlook	1.15 11	1,2,3,4 3	30	0	90	100	97	99	99	93	41.3
Poast Outlook Outlook	1.15 11 11	1,2,3,4 3 4	32	10	90	97	100	100	99	93	41.9
Outlook	11	3	24	5	98	100	100	96	85	79	38.5
Select	0.5	1,2,3,4	23	2	91	100	98	95	100	68	40.9
Assure II	0.44	1,2,3,4	21	0	83	100	95	83	97	67	34.1
Untreated			0	0	0	0	0	0	0	0	6.7
LSD (0.05)			13	8	9	4	4	4	14	12	5.7

*The herbicides listed were applied at the indicated times in combination with one of the four applications of the standard micro-rate of Progress (1.3 oz ai/acre), Upbeet (0.063 oz ai/acre), Stinger (0.5 oz ai/acre), and MSO (1.5% v/v).
†Treatments were applied on April 24 (1), April 30 (2), May 7 (3), and May 12 (4).
‡Weed control was evaluated on June 25. Late barnyardgrass control was evaluated on September 23.
§Sugar beets were harvested on October 3.

SUGAR BEET TOLERANCE AND WEED CONTROL WITH POSTEMERGENCE COMBINATIONS OF OUTLOOK®

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Introduction

As weed problems and management systems change, it is important to evaluate new herbicides with potential use in sugar beets. Continual review of pesticides by the U.S. Environmental Protection Agency (EPA) also may reduce the herbicides available for use in sugar beets in the future. In these trials, Outlook (dimethenamid-p), was evaluated for crop tolerance and weed control from postemergence applications to sugar beets. Outlook is a soil-active herbicide that provides control of annual grasses as well as control or suppression of several small-seeded annual broadleaf weeds.

Methods

General

Trials were established at the Malheur Experiment Station under furrow irrigation on April 12, 2001. Sugar beets (Hilleshog 'WS PM-21') were planted in 22-inch rows at a 2-inch seed spacing. Sugar beets were thinned to 8-inch spacings on May 16. Plots were sidedressed on May 23 with 200 lbs N/acre as urea. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots four rows wide and 27 ft long were arranged in a randomized complete block design. Roundup (0.75 lb ai/acre) was applied preemergence to all trials. 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 2.

Sugar Beet Tolerance to Outlook

Outlook was applied at either 0.64 or 0.96 lb ai/acre to two-leaf sugar beets in various tank-mix combinations including standard rates of Progress (0.33 lb ai/acre), UpBeet (0.016 lb ai/acre), and Stinger (0.094 lb ai/acre). All plots were treated with Progress plus UpBeet when sugar beets were in the cotyledon stage of growth on April 25. On May 4, Progress, UpBeet, and Stinger; Progress plus UpBeet; Outlook (0.64 lb ai/acre) with Progress and UpBeet; and Outlook (0.64 and 0.96 lb ai/acre) in combination with Progress, UpBeet, and Stinger were applied to two-leaf sugar beets. Tank-mix combinations of Progress and UpBeet with and without Stinger were applied to eight-leaf sugar beets on May 17. Weed escapes following herbicide treatments were removed by hand to eliminate any weed competition. Experimental plots were evaluated for sugar beet injury throughout the season. Sugar beet injury from treatment combinations with Outlook were compared to the hand-weeded and standard rate treatments without Outlook. In addition to sugar beet root yield, 16 sugar beets from each plot were sent to the Hilleshog Mono-Hy Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity.

Weed Control with Outlook in Sugar Beets

Outlook (0.32 or 0.64 lb ai/acre) was applied at various application timings combined with standard rates of Progress (0.33 lb ai/acre), UpBeet (0.016 lb ai/acre), and Stinger (0.094 lb ai/acre). Treatments applied on April 25 to cotyledon sugar beets consisted of Progress (0.33 lb ai/acre) plus UpBeet (0.016 lb ai/acre) or Progress plus UpBeet plus Outlook (0.32 or 0.64 lb ai/acre). On May 4, Progress, UpBeet, and Stinger were applied to two-leaf sugar beets with or without Outlook (0.32 or 0.64 lb ai/acre). Treatments applied to eight-leaf sugar beets on May 17 consisted of Progress, UpBeet, and Stinger with and without Outlook (0.32 or 0.64 lb ai/acre). Weed control evaluations were made over the course of the growing season. Weed control with combinations containing Outlook were compared to standard rate treatments applied either two or three times.

Results and Discussion

Sugar Beet Tolerance to Outlook

Eight days following two-leaf application, sugar beet injury was greatest from treatment combinations of Outlook (0.64 or 0.96 lb ai/acre) with Progress (0.33 lb ai/acre), UpBeet (0.016 lb ai/acre), and Stinger (0.094 lb ai/acre) (Table 1). Treatments with tank-mix combinations containing Stinger displayed the greatest sugar beet injury on May 24. On June 2, all treatments caused greater sugar beet injury than Progress plus UpBeet applied to cotyledon, two-leaf, and eight-leaf sugar beets. By June 24, significant injury was not apparent for any treatment. Sugar beet root yield and estimated recoverable sucrose (ERS) were significantly lower for plots treated with Outlook (0.96 lb ai/acre) in combination with Progress, UpBeet, and Stinger than with the hand-weeded control (Table 1). Notwithstanding the observed injury, there were no differences in percent sucrose or sucrose percent extraction among treatments.

Weed Control with Outlook in Sugar Beets.

In general, redroot pigweed control was greatest among treatments having three applications compared with the two application treatments (Table 2). All treatments provided greater than 89 percent control of lambsquarters on June 25. Hairy nightshade control was greatest when Outlook was applied in the second and/or third applications as opposed to the first application. Barnyardgrass control, evaluated on June 4, was improved when Outlook was included in a two-application treatment. However, barnyardgrass control was similar among treatments with tank-mix combinations of Outlook and treatments having three applications without Outlook. Despite differences in weed control and sugar beet injury, all herbicide treatments provided similar root yields ranging from 39 to 43.5 tons/acre (Table 3).

Table 1. Sugar beet tolerance to Outlook combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Injury				Sugar beet yield			
Treatment	Rate	Timing*	5-12	5-24	6-2	6-24	Root yield	Sucrose	Extraction	ERS^
	lb ai/acre		------------------	%	------------------		ton/acre	-----------%----------		lb/acre
Hand weeded	--	--	0	0	0	3	46.3	16.8	92.9	14,445
Progress + UpBeet	0.33 + 0.016	1	36	49	25	5	42.6	16.7	92.9	13,202
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	2								
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	3								
Progress + UpBeet	0.33 + 0.016	1	35	37	15	4	44.8	17.0	92.9	14,093
Progress + UpBeet	0.33 + 0.016	2								
Progress + UpBeet	0.33 + 0.016	3								
Progress + UpBeet	0.33 + 0.016	1	38	37	25	7	44.9	16.8	93.0	14,050
Progress + UpBeet + Outlook	0.33 + 0.016 + 0.64	2								
Progress + UpBeet	0.33 + 0.016	3								
Progress + UpBeet	0.33 + 0.016	1	40	46	27	5	43.1	16.9	92.9	13,566
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.64	2								
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	3								
Progress + UpBeet	0.33 + 0.016	1	48	51	34	5	40.2	17.1	93.3	12,826
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.96	2								
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	3								
LSD (0.05)			8	6	10	NS	5.1	NS	NS	1,612

*Application timings were (1) April 25 to cotyledon sugar beets, (2) May 4 to two-leaf sugar beets, and (3) May 17 to eight-leaf sugar beets.

^Estimated recoverable sucrose.

Table 2. Weed control with postemergence Outlook combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Weed control							
			Pigweed		Lambsquarters		H. nightshade		Barnyardgrass	
Treatment	Rate	Timing*	6-25	8-22	6-25	8-22	6-25	8-22	5-24	6-4
	lb ai/acre		%							
Untreated	--	--	0	0	0	0	0	0	0	0
Progress + UpBeet	0.33 + 0.016	1	92	85	98	88	92	89	88	80
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	2								
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	3								
Progress + UpBeet + Outlook	0.33 + 0.016 + 0.64	1	81	78	94	86	79	78	92	82
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	2								
Progress + UpBeet	0.33 + 0.016	1	80	77	100	98	92	89	87	80
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.64	2								
Progress + UpBeet	0.33 + 0.016	1	95	84	97	93	98	91	92	85
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	2								
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.64	3								
Progress + UpBeet	0.33 + 0.016	1	98	93	100	98	100	98	91	88
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.32	2								
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.32	3								
Progress + UpBeet	0.33 + 0.016	1	83	79	100	95	95	87	50	63
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	2								
Progress + UpBeet + Outlook	0.33 + 0.016 + 0.32	1	88	74	89	90	90	79	74	81
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.32	2								
LSD (0.05)			14	17	8	12	14	18	30	10

*Application timings were (1) April 25 to cotyledon sugar beets, (2) May 4 to two-leaf sugar beets, and (3) May 17 to eight-leaf sugar beets.

Table 3. Sugar beet injury and root yield with postemergence Outlook combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	Timing*	Injury 5-12	Injury 5-24	Suar beet Yield
	lb ai/acre		%	%	ton/acre
Untreated	--	--	0	0	10
Progress + UpBeet	0.33 + 0.016	1	37	44	39
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	2			
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	3			
Progress + UpBeet + Outlook	0.33 + 0.016 + 0.64	1	38	22	42
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	2			
Progress + UpBeet	0.33 + 0.016	1	53	32	41
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.64	2			
Progress + UpBeet	0.33 + 0.016	1	43	47	42
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	2			
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.64	3			
Progress + UpBeet	0.33 + 0.016	1	41	47	44
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.32	2			
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.32	3			
Progress + UpBeet	0.33 + 0.016	1	44	23	42
Progress + UpBeet + Stinger	0.33 + 0.016 + 0.094	2			
Progress + UpBeet + Outlook	0.33 + 0.016 + 0.32	1	47	23	44
Progress + UpBeet + Stinger + Outlook	0.33 + 0.016 + 0.094 + 0.32	2			
LSD (0.05)			8	7	NS

*Application timings were (1) April 25 to cotyledon sugar beets, (2) May 4 to two-leaf sugar beets, and (3) May 17 to eight-leaf sugar beets.

BETAMIX®, PROGRESS®, AND BETANEX® FORMULATIONS FOR WEED CONTROL IN SUGAR BEETS

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Introduction

Pressure from the U.S. Environmental Protection Agency to remove one of the carriers from the current formulations of Betamix, Progress, and Betanex has lead Aventis to produce formulations of these products that use a plant-based oil as a carrier. These oil-based formulations need to be compared to current formulations to determine if sugar beet tolerance and weed control efficacy are similar.

Methods

Experimental oil-based formulations of Progress, Betamix, and Betanex were compared to commercial formulations for sugar beet tolerance and weed control efficacy.

Both the experimental and commercial formulations were applied alone at 4.0 oz ai/acre and in a micro-rate treatment at 1.28 oz ai/acre in combination with UpBeet (0.063 oz ai/acre), Stinger (0.5 oz ai/acre), and Scoil (methylated seed oil) (1.5 percent v/v). The experimental and commercial formulations were applied alone three times with the first application to cotyledon beets, the second to two-leaf beets, and the third to eight-leaf beets. The applications were made on April 25, May 3, and May 17. The micro-rate treatments were applied four times with the first application to cotyledon beets on April 25, two-leaf on May 3, four-leaf on May 8, and eight-leaf on May 17.

Results and Discussion

Sugar beet injury ranged from 14 to 32 percent on May 12 and did not differ between experimental oil-based formulations and commercial formulations of Progress, Betamix, or Betanex (Table 1). The experimental formulations also displayed similar injury compared to their respective commercial formulations when applied in a micro-rate with Upbeet, Stinger, and Scoil. Sugar beet injury was not significant after June 25.

In general, weed control was similar between the experimental oil-based and commercial formulations whether applied alone or in the micro-rate treatment (Table 2). The only differences were observed with common lambsquarters control evaluated on June 25. The commercial formulations of Progress and Betanex provided greater control of common lambsquarters than did their respective experimental oil-based formulations.

Sugar beet yields were similar with the experimental oil-based formulations compared to their respective commercial formulations (Table 1). Sugar beet root yields ranged from a low of 31 ton/acre with the experimental oil-based formulation of Progress applied alone to a high of 46 ton/acre with the micro-rate treatment containing the commercial Betanex formulation.

Table 1. Sugar beet injury and yield with experimental and commercial Progress, Betamix, and Betanex formulations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	Timing*	Injury 5-12	Injury 5-24	Injury 6-4	Injury 6-25	Sugar beet yield
	oz ai/acre	Leaf	%				ton/acre
New Progress New Progress New Progress	4.0 5.28 5.28	Cot 2-leaf 8-leaf	22	25	23	2	31
Progress Progress Progress	4.0 5.28 5.28	Cot 2-leaf 8-leaf	23	21	14	0	38
New Progress + UpBeet + Stinger + Scoil	1.28 + 0.063 + 0.5 + 1.5% v/v	Cot, 2, 4, 8-leaf	17	17	9	0	41
Progress + UpBeet + Stinger + Scoil	1.28 + 1.0 + 0.5 + 1.5% v/v	Cot, 2, 4, 8-leaf	22	20	19	0	41
New Betamix New Betamix New Betamix	4.00 5.28 5.28	Cot 2-leaf 8-leaf	25	21	18	3	37
Betamix Betamix Betamix	4.0 5.28 5.28	Cot 2-leaf 8-leaf	30	23	20	0	35
New Betamix + UpBeet + Stinger + Scoil	1.28 + 0.063 + 0.5 + 1.5% v/v	Cot, 2, 4, 8-leaf	17	18	17	0	40
Betamix + UpBeet + Stinger + Scoil	1.28 + 0.063 + 0.5 + 1.5% v/v	Cot, 2, 4, 8-leaf	19	20	15	3	43
New Betanex New Betanex New Betanex	4.0 5.28 5.28	Cot 2-leaf 8-leaf	21	19	12	0	41
Betanex Betanex Betanex	4.0 5.28 5.28	Cot 2-leaf 8-leaf	14	17	15	5	43
New Betanex + UpBeet + Stinger + Scoil	1.28 + 0.063 + 0.5 + 1.5% v/v	Cot, 2, 4, 8-leaf	24	22	19	3	45
Betanex + UpBeet + Stinger + Scoil	1.28 + 0.063 + 0.5 + 1.5 % v/v	Cot, 2, 4, 8-leaf	32	24	20	0	46
Untreated	--	--	0	0	0	0	16
LSD (0.05)			11	10	10	NS	10

*Applications were made to cotyledon (Cot) sugar beets on April 25, two-leaf (2-leaf) May 3, four-leaf (4-leaf) May 8, and eight-leaf (8-leaf) on May 17.

Table 2. Weed control with experimental and commercial Progress, Betamix, and Betanex formulations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Weed control					
			Redroot pigweed		Common lambsquarters		Hairy nightshade	
Treatment	Rate	Timing*	6-4	6-25	6-4	6-25	6-4	6-25
	oz ai/acre	Leaf	%					
New Progress New Progress New Progress	4.0 5.28 5.28	Cot 2-leaf 8-leaf	86	43	98	87	89	61
Progress Progress Progress	4.0 5.28 5.28	Cot 2-leaf 8-leaf	90	64	98	98	91	72
New Progress + UpBeet + Stinger + Scoil	1.28 + 0.063 + 0.5 + 1.5% v/v	Cot, 2, 4, 8-leaf	98	84	100	100	100	97
Progress + UpBeet + Stinger + Scoil	1.28 + 1.0 + 0.5 + 1.5% v/v	Cot, 2, 4, 8-leaf	97	78	100	97	96	91
New Betamix New Betamix New Betamix	4.00 5.28 5.28	Cot 2-leaf 8-leaf	91	74	99	98	89	70
Betamix Betamix Betamix	4.0 5.28 5.28	Cot 2-leaf 8-leaf	94	74	100	95	87	65
New Betamix + UpBeet + Stinger + Scoil	1.28 + 0.063 + 0.5 + 1.5% v/v	Cot, 2, 4, 8-leaf	96	83	100	100	97	92
Betamix + UpBeet + Stinger + Scoil	1.28 + 0.063 + 0.5 + 1.5% v/v	Cot, 2, 4, 8-leaf	99	92	100	100	99	97
New Betanex New Betanex New Betanex	4.0 5.28 5.28	Cot 2-leaf 8-leaf	99	91	100	92	88	68
Betanex Betanex Betanex	4.0 5.28 5.28	Cot 2-leaf 8-leaf	99	95	99	100	91	77
New Betanex + UpBeet + Stinger + Scoil	1.28 + 0.063 + 0.5 + 1.5% v/v	Cot, 2, 4, 8-leaf	99	97	98	100	99	98
Betanex + UpBeet + Stinger + Scoil	1.28 + 0.063 + 0.5 + 1.5 % v/v	Cot, 2, 4, 8-leaf	99	97	99	100	99	100
Untreated	--	--	0	0	0	0	0	0
LSD (0.05)			7	25	2	7	12	29

*Applications were made to cotyledon (Cot) sugar beets on April 25, two-leaf (2-leaf) May 3, four-leaf (4-leaf) May 8, and eight-leaf (8-leaf) on May 17.

YELLOW NUTSEDGE CONTROL IN SUGAR BEETS

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Introduction

Yellow nutsedge is an increasing weed problem in the Treasure Valley in several crops, including sugar beets. Different herbicides with potential to assist in yellow nutsedge control and with the possibility of registration were added to the Betamix, Upbeet, and Stinger. Different rates and application timings with various products were evaluated.

Methods

The study was conducted in a field with a heavy infestation of yellow nutsedge. The soil was a Feltham loamy fine sand with pH 8.2 and 1.4 percent organic matter. The field was plowed in the fall of 2000 and harrowed and bedded on March 16. On April 13, 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 directly after planting. After beet emergence, the stand was hand thinned to one plant every 8 inches. Plots were four rows wide, 27 ft long, and arranged in a randomized complete block design. The trial was sidedressed on May 24 with 200 lb N/acre as urea. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Postemergence treatments were applied three times. Treatments were applied to two-leaf beets on May 8, four-leaf beets on May 17, and six-leaf beets on May 24. Sugar beet injury and nutsedge control were evaluated throughout the growing season. Sugar beet yields were not taken.

Standard treatments consisted of Betamix (0.25 lb ai/acre) and Upbeet (0.0156 lb ai/acre) applied to two-leaf beets and Betamix, Upbeet, and Stinger (0.094 lb ai/acre) applied to four-leaf and six-leaf sugar beets. Variations of the standard treatment included increasing the Betamix rate to 0.5 lb ai/acre at each application timing, increasing the Upbeet rate to 0.0259 lb ai/acre for each timing, or increasing the last application of Upbeet to 0.0312 lb ai/acre. Dual Magnum (1.3 lb ai/acre) or Outlook (0.64 lb ai/acre) was added to the standard treatments at either the two, four, or six-leaf application timing. Dual Magnum or Outlook were also added to the standard treatment at both the two and six-leaf application timings. Eptam (3.0 lb ai/acre) or Ro-Neet (3.0 lb ai/acre) were applied with the standard treatment at the six-leaf timing as a lay-by treatment.

Results and Discussion

All treatments exhibited significant sugar beet injury compared to the untreated check (18-35 percent) (Table 1). In general, the standard treatment with Dual Magnum or Outlook added at the two- and six-leaf stages had higher injury than most treatments. The standard treatment with Dual Magnum added at the four-leaf stage and the standard with Ro-Neet added at the six-leaf stage were also among those with the highest injury.

On June 7, yellow nutsedge control for all treatments was between 58 and 85 percent. The standard treatment when either Dual Magnum or Outlook were applied at both the two- and six-leaf stage were among the highest in yellow nutsedge control at 81 and 85 percent, respectively. It appears that yellow nutsedge control is improved when Dual Magnum or Outlook are added to the first or second application timing, but when delayed until the six-leaf stage, there is no gain in control over the standard treatment alone. There were also no benefits to adding Eptam or Ro-Neet to the six-leaf timing. On August 2, yellow nutsedge control was between 69 and 93 percent. The best treatment, the standard plus Dual Magnum added to the two- and six-leaf application, was statistically superior to all the treatments that included only Betamix, Upbeet, and Stinger.

Table 1. Sugar beet injury and yellow nutsedge control with soil-active herbicides added to standard sugar beet treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment	Rate	Timing*	Crop injury	Nutsedge control	
			6-7	6-7	8-2
	lb ai/acre	Leaf	---	%	---
Betamix+ Upbeet	0.25 + 0.016	2-lf	21	61	69
Betamix+ Upbeet + Stinger	0.25 + 0.016 + 0.094	4-lf			
Betamix+ Upbeet + Stinger	0.25 + 0.016 + 0.094	6-lf			
Betamix + Upbeet + Dual Magnum	0.25 + 0.016 + 1.3	2-lf	21	78	83
Betamix + Upbeet + Stinger	0.25 + 0.0156 + 0.094	4-lf			
Betamix + Upbeet + Stinger	0.25 + 0.0156 + 0.094	6-lf			
Betamix + Upbeet + Outlook	0.25 + 0.016 + 0.64	2-lf	18	75	73
Betamix + Upbeet + Stinger	0.25 + 0.016 + 0.094	4-lf			
Betamix + Upbeet + Stinger	0.25 + 0.016 + 0.094	6-lf			
Betamix + Upbeet	0.25 + 0.016	2-lf	31	75	81
Betamix + Upbeet + Stinger + Dual Magnum	0.25 + 0.0156 + 0.094 + 1.3	4-lf			
Betamix + Upbeet + Stinger	0.25 + 0.016 + 0.094	6-lf			
Betamix + Upbeet	0.25 + 0.016	2-lf	25	72	75
Betamix + Upbeet + Stinger + Outlook	0.25 + 0.016 + 0.094 + 0.64	4-lf			
Betamix + Upbeet + Stinger	0.25 + 0.016 + 0.094	6-lf			

Table 1. *(continued)* Sugar beet injury and yellow nutsedge control with soil-active herbicides added to the standard sugar beet treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Crop injury	Nutsedge control	
Treatment	Rate	Timing*	6-7	6-7	8-2
	lb ai/acre	Leaf	--------------------	%	--------------------
Betamix + Upbeet Betamix + Upbeet + Stinger Betamix + Upbeet + Stinger	0.25 + 0.026 0.25 + 0.026 + 0.094 0.25 + 0.026 + 0.094	2-lf 4-lf 6-lf	25	62	73
Betamix + Upbeet Betamix + Upbeet + Stinger Betamix + Upbeet + Stinger	0.5 + 0.016 0.5 + 0.016 + 0.094 0.5 + 0.016 + 0.094	2-lf 4-lf 6-lf	26	58	72
Betamix + Upbeet Betamix + Upbeet + Stinger Betamix + Upbeet + Stinger	0.25 + 0.016 0.25 + 0.016 + 0.094 0.25 + 0.031 + 0.094	2-lf 4-lf 6-lf	23	68	79
Betamix + Upbeet Betamix + Upbeet + Stinger Betamix + Upbeet + Stinger + Eptam	0.25 + 0.016 0.25 + 0.016 + 0.094 0.25 + 0.016 + 0.094 + 3.0	2-lf 4-lf 6-lf	21	60	75
Betamix+Upbeet Betamix+Upbeet + Stinger Betamix+Upbeet + Stinger + Ro-Neet	0.25 + 0.016 0.25 + 0.016 + 0.094 0.25 + 0.016 + 0.094 + 3.0	2-lf 4-lf 6-lf	32	70	85
Betamix + Upbeet Betamix + Upbeet + Stinger Betamix + Upbeet + Stinger + Dual Magnum	0.25 + 0.016 0.25 + 0.016 + 0.094 0.25 + 0.016 + 0.094 + 1.3	2-lf 4-lf 6-lf	24	67	83
Betamix + Upbeet Betamix + Upbeet + Stinger Betamix + Upbeet + Stinger + Outlook	0.25 + 0.016 0.25 + 0.016 + 0.094 0.25 + 0.016 + 0.094 + 0.64	2-lf 4-lf 6-lf	23	68	80
Betamix + Upbeet + Dual Magnum Betamix + Upbeet + Stinger Betamix + Upbeet + Stinger + Dual Magnum	0.25 + 0.016 + 1.3 0.25 + 0.016 + 0.094 0.25 + 0.016 + 0.094 + 1.3	2-lf 4-lf 6-lf	30	81	93
Betamix + Upbeet + Outlook Betamix + Upbeet + Stinger Betamix + Upbeet + Stinger + Outlook	0.25 + 0.016 + 0.64 0.25 + 0.016 + 0.094 0.25 + 0.016 + 0.94 + 0.64	2-lf 4-lf 6-lf	35	85	76
Betamix + Upbeet Betamix + Upbeet + Stinger Betamix + Upbeet + Stinger + Ro-Neet	0.25 + 0.016 0.25 + 0.016 + 0.094 0.25 + 0.016 + 0.094 + 3.0	2-lf 4-lf 6-lf	26	67	83
Untreated	--	--	0	0	36
LSD (0.05)			9	11	19

*Two-leaf (2-lf) application was made on May 8, four-leaf (4-lf) on May 17, and six-leaf (6-lf) on May 24.

2001 SMALL GRAIN VARIETY TRIALS

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Introduction

Malheur Experiment Station (MES) provides one location for the statewide cereal grain variety trials that are planted at several sites across Oregon every year. The MES location provides a furrow-irrigated site for comparing cereal grain variety performance. Plant breeders gain information on the field performance of advanced lines in varied production regions. Growers can compare yields of newly released varieties to the current standards, and also see how some of the varieties in different market classes of wheat, barley, and triticale perform.

Methods

2001 Winter Grain Variety Trials

The grain trials followed sweet corn. The corn stalks were flail mowed on September 8, 2000, then the field was disked and preplant fertilizer was broadcast at 50 lb N/acre and 100 lb P/acre. The soil was deep ripped, plowed, and groundhogged to prepare the seedbed. The field was corrugated into 30-inch rows. Seeds were planted October 30, 2000 with a plot seeder, in plots 5 x 20 ft, then the field was recorrugated.

Eight club wheats, 1 durum wheat, 4 hard white winter wheats, 3 hard red winter wheats, 18 soft white winter wheats, 3 triticales, 1 oat, 1 rye, and a 50/50 blend of 2 soft white wheats were planted in the winter cereals trial. Seed of all varieties was treated with Raxil fungicide and Gaucho insecticide. Grain was planted at 30 live seeds/ft^2, which corresponds to a seeding rate of approximately 110 lb/acre.

The winter barley trial was comprised of eight six-row barleys, treated with Raxil fungicide and Gaucho insecticide, and planted at 30 live seeds/ft^2. The winter cereals trial and the winter barley trial were both replicated three times. A soil sample was taken from the field on February 26, 2001. The soil analysis showed ammonia and nitrate forms of N in the top 2 ft of soil totaled 121 lb N/acre, 30 ppm extractable P, 260 ppm K, pH 6.8, and 1.2 percent organic matter.

On April 27, just before the first irrigation, urea prills fertilizer was broadcast over both winter trials to apply N at 47 lb/acre. Broadleaf weeds were controlled with Bronate at 1qt/acre applied April 18. The field was furrow irrigated for 24 hours on April 27, May 24, and June 13. Alleys 3.3 ft wide were cut with a sicklebar mower on June 22. Grain samples were harvested on July 23 with a Hege plot combine.

2001 Spring Cereals Variety Trials

The 2001 spring wheat trial was divided into two separate trials; a hard wheat variety trial and a soft wheat variety trial, in order to allow nitrogen fertilizer to be applied to only the hard wheats to promote optimum protein content. The spring grain trials were in the same field alongside the winter grain trials, and had the same field preparation and fertilizer of 50 lb N/acre and 100 lb P/acre applied in the fall. The field was corrugated into 30-inch beds and left through the winter. On March 20, 2001, preplant fertilizer was broadcast and incorporated to supply 93 lb N/acre, 32 lb SO_4/acre, 4 lb Zn/acre, 1 lb Cu/acre, and 1 lb B/acre.

Seeds were planted on March 23 with a plot seeder, in plots 5 x 20 ft. Broadleaf weeds were controlled in the spring grain trials with Bronate at 1 qt/acre applied May 18. The field was recorrugated on 30-inch rows immediately after planting, and received the first irrigation on April 27. The field was furrow irrigated for 24 hours on April 27, May 24, and June 13. The spring hard wheat trial received an extra 45 lb N/acre before anthesis (the beginning of flowering). Immediately before the May 24 irrigation, urea prills were placed in each irrigation furrow at the top end of every plot in the hard spring wheat trial to provide water-run nitrogen fertilizer.

The spring hard wheat variety trial was comprised of 13 hard red spring wheats, 9 hard white spring wheats, and 2 soft white spring wheats as checks. The spring soft wheat variety trial was comprised of 13 soft white wheat varieties, with 1 club, 1 hard red, and 1 hard white wheat included as checks. The spring barley trial was comprised of four two-row malting varieties, five two-row feed varieties, one two-row feed or malt variety, two six-row feed varieties, four six-row dual use feed or malting varieties, one six-row malt barley variety, and three hull-less oat varieties. Seed of all spring grain was treated with Raxil fungicide and Gaucho insecticide. Plots were replicated three times in both of the spring wheat trials and in the spring barley trial.

Alleys 3.3 ft wide were cut with a sicklebar mower on June 25. Grain samples were harvested in the spring cereal trials on July 24 with a Hege plot combine. All of the grain samples from the winter and spring variety trials were taken to the Oregon State University Cereals Lab at Corvallis where they were cleaned and weighed. Moisture, test weight, and protein were measured. Data were analyzed and tabulated, and data from each location of the statewide cereal trials were posted on the internet at www.css.orst.edu/cereals as they were completed.

Results

At the Malheur Experiment Station in 2001, the summer was warm and sunny, with few evening windstorms, and no hailstorms; consequently all the cereal trials grew very well, with some lodging in the winter grain trials, and no lodging in the spring grain trials. Grain maturity was less uniform than normal, possibly due to unusual temperature fluctuations in April and May.

Winter Cereals Trial
'OR939526', at 148 bu/acre, 'Stephens' at 138 bu/acre, 'Malcolm' at 137 bu/acre, 'ID52814A' at 130 bu/acre, 'WA7853' at 130 bu/acre, 'ID-B-96' at 129 bu/acre, 'Brundage' at 128 bu/acre, 'ID17113A' at 128 bu/acre, 'Weatherford' at 128 bu/acre, and 'OR 939528' at 128 bu/acre were the soft white winter wheat varieties that yielded well (Table 1). 'Malcolm', 'ID-B-96', 'Weatherford', 'OR941044', and 'Hubbard' all showed some lodging. A 50/50 mix of 'Madsen'/'Stephens' yielded the same as 'Madsen' alone, 123 bu/acre, which was not significantly less than 'Stephens' alone.

For varieties of hard red winter wheat, 'Declo' produced 137 bu/acre, 'ID517' 125 bu/acre, and 'Boundary' yielded 120 bu/acre. 'Rhode' club wheat yielded 142 bu/acre, with 'Hiller', 'Bruehl', and 'Temple' not significantly different. 'Coda', a club wheat, and 'IDO550', a hard white, had 63 and 100 percent lodging, respectively, which contributed to their reduced yields. 'Bogo' triticale yielded 143 bu/acre, 'KFT31' triticale yielded 133 bu/acre, and 'Alzo' triticale yielded 111 bu/acre.

Winter Barley Trial
In the winter barley variety trial 'Scio' at 5,754 lb/acre, and 'Stab-113' at 5,163 lb/acre were among the highest yielding (Table 2). Lodging was present in all of the winter barley varieties in this trial, indicating that the nitrogen fertilizer was excessive.

Spring Hard Wheat Trial
Yields of hard white spring wheats were 'WA 7901' at 120 bu/acre, 'WA7899' at 113 bu/acre, 'Lolo' at 112 bu/acre, 'WA7900' at 111 bu/acre, 'Sunco' at 109 bu/acre, and 'IDO 560' at 105 bu/acre (Table 3) . In the hard red market class, the varieties with yield higher than 100 bu/acre were 'Jefferson' at 114 bu/acre, 'IDO 545' at 112 bu/acre, 'OR 4910028' at 111 bu/acre, 'Yecora Rojo' at 107 bu/acre, 'OR 4920002' at 104 bu/acre, and 'IDO 377S' at 102 bu/acre.

Among the hard reds, 'Yecora Rojo' at 14.1 percent protein, 'IDO 557' at 14.5 percent protein, 'WPB-936' at 14.3 percent protein, and 'Tara' at 14.6 percent protein, all attained the minimum standard of protein (14 percent) the hard wheats require for acceptable milling and baking quality in their customary uses. Protein among the hard white spring wheats ranged from 11.2 to 12.6 percent.

Among the highest yield in the spring hard wheat trial was 'Winsome' hard white wheat with 124 bu/acre, when planted at 45 seeds/ft^2 (for a seeding rate of approximately 143 lb/acre) (Table 3). 'Winsome' planted at the standard rate of 30 seeds/ft^2 (95 lb/acre seeding rate) yielded 123 bu/acre, and 'Winsome' at 20 seeds/ft^2 (64 lb/acre seeding rate) yielded 116 bu/acre. 'Penawawa' soft white spring wheat, included in this hard wheat trial as a check, produced 124 bu/acre, equal to 'Winsome' at the high seeding rate.

There was no lodging in the spring hard wheat trial, indicating the nitrogen supply (121 lb N/acre from the soil test, plus 93 lb N/acre applied preplant, plus 45 lb N/acre water-run pre-anthesis, for a soil system total of 259 lb N/acre) could have been higher.

With a higher N fertilizer level, weaker-strawed varieties such as 'IDO377S' and 'Lolo' might show some lodging, and stronger-strawed varieties such as 'Yecora Rojo' and 'Hank' might increase in yield and protein content. The difficulty is in predicting how much mineralized N will be available to be taken up by the crop in the growing season. Based on the trial average yield of 108 bu/acre, and a "rule-of-thumb" total nitrogen requirement for irrigated hard spring wheat of 3.5 lb N/bu, the system total N would have been 378 lb N/acre, suggesting 119 lb N/acre was mineralized N.

Split applications of nitrogen fertilizer, or an application of nitrogen at, or just before, anthesis, have not reliably increased hard wheat protein levels in irrigated cropping systems to 14 percent and above. Hard wheats grown in dryland conditions usually have acceptable protein content, but the low grain yields typical of dryland systems would be economically unacceptable for growers in our area, compared to the productivity of irrigated soft wheats.

Spring Soft Wheat Trial

The trial average yield was 103 bu/acre, and there were no differences in yield at the 5 percent level of statistical probability (Table 4). 'WA 7884' and 'Challis' each produced 114 bu/acre. Protein content ranged from 9.5 percent for 'Challis' to 11.1 percent for 'Zak'. There was no lodging in the spring soft wheat trial.

Spring Barley Trial

Spring barley yield reached 6,000 lb/acre for the two-row feed variety 'Farmington', with 'Stab-113' at 5,541 lb/acre, and 'Tango' at 5,097 lb/acre also among the highest yielding spring barleys (Table 5). The highest yielding hull-less oat variety was 'Cayuse' at 3,182 lb/acre, with 16.3 percent protein. There was no lodging in the spring barley trial.

Table 1. Winter wheat and triticale yield, test weight, protein percentage, height at maturity, and date of 50 percent heading, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Variety	Market class*	Yield	Test weight	Protein	Height	Heading	Lodging
		bu/acre†	lb/bu	%	in	day	%
Rohde	Club	122	53.7	10.3	39	May 30	0
Rely	Club	109	57.3	10	41	June 3	30
Coda	Club	106	58.8	10.7	37	June 6	63
Hiller	Club	105	55.3	10.2	40	June 3	20
WA7855	Club	105	56.3	10.2	41	June 6	0
Temple	Club	96	59.2	10.4	38	May 29	0
Edwin	Club	85	57.9	11.1	42	May 31	33
Bruehl	Club	56	48.2	10.7	41	June 4	0
Connie	Durum	120	63.1	11.7	37	May 26	0
Declo	HR	137	61.4	11.2	39	June 1	0
ID517	HR	125	61	10.6	36	May 27	10
Boundry	HR	120	60.5	11.1	40	May 30	0
OR 850513-19	HW	126	62.3	10.3	39	May 30	0
OR 850513-8	HW	122	60.1	10.3	39	May 30	0
OR 941904	HW	111	59.9	10.4	41	June 5	0
ID550	HW	89	59.6	10.4	45	May 30	100
Kolding oat	Oat	46	38.7	16.7	52	June 12	63
Rifle	Rye	101	55.6	9.1	43	May 21	20
OR 939526	SW	148	59.5	10	42	May 29	0
Stephens	SW	138	58.8	10.9	39	May 28	0
Malcolm	SW	137	60	10.4	41	June 1	10
ID52814A	SW	130	59.4	9.5	43	June 6	0
WA7853	SW	130	60.1	9.8	44	June 5	0
ID-B-96	SW	129	57.9	9.6	39	June 6	10
Brundage	SW	128	62.3	9.7	36	May 25	0
ID17113A	SW	128	58.6	10	38	May 31	0
Weatherford	SW	128	58.1	10	42	June 7	15
OR 939528	SW	128	58.4	10.3	43	May 30	0
Madsen/Stephens	SW	123	60.3	9.8	39	May 29	0
Madsen	SW	123	59.7	9.8	38	June 6	0
OR 941044	SW	123	62.1	10.3	42	June 4	10
Rod	SW	119	59	10.1	40	June 6	0
OR 943560	SW	117	59.7	10.3	42	May 30	0
Hubbard (ID10420A)	SW	116	60.7	10.2	44	June 2	10
OR 941899	SW	115	59	10	42	June 6	0
Yamhill	SW	102	57.6	9.8	43	June 4	0
Foote	SW	96	57	8.3	42	May 30	0
Bogo	Triticale	143	57.9	11.1	46	May 27	0
KFT31	Triticale	133	59.7	11.6	47	May 25	0
Alzo	Triticale	122	58	11.2	48	May 29	0
Mean		116	58.3	10.5	41	June 1	
LSD (0.05)		24	6	1.2			

*HR = hard red, HW = hard white, SW = soft white.

†Adjusted to 10% moisture, 60 lb/bu.

Table 2. Winter barley yield, test weight, protein percentage, height at maturity, date of 50 percent heading, and lodging percentage, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Variety	Market class*	Yield	Test weight	Protein	Height	Heading day	Lodging
		lb/acre	lb/bu	%	in		%
Scio	6RF	5,754	51	12.5	40	May 25	35
Kold	6RF	3,919	51.7	12.4	41	May 24	57
Strider	6RF	3,051	53.7	11.6	39	May 23	70
Stab-113	6RF/M	5,163	53.3	11.9	40	May 22	30
Stab-7	6RF/M	4,352	52.6	12.2	41	May 20	65
Stab-47	6RF/M	3,632	52.7	13.3	46	May 18	33
Kab-37	6RF/M	3,162	52.6	11.5	41	May 25	17
88Ab536	6RM	3,498	53.2	13.7	43	May 18	80
Mean		4,066	52.6	12.4	41	May 22	48
LSD (0.05)		1,301	ns	1.1			

*6RF = six-row feed, 6RF/M = six-row feed or malt, 6RM = six-row malt.

Table 3. Spring hard wheat yield, test weight, protein percentage, height at maturity, and date of 50 percent heading, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Variety	Market class*	Yield	Test weight	Protein	Height	Heading day
		bu/acre†	lb/bu	%	in	
Jefferson	HR	114	61.1	13.2	38	June 5
IDO 545	HR	112	60.5	12.3	39	June 3
OR 4910028	HR	111	59.7	12.2	35	June 2
Yecora Rojo	HR	107	62.2	14.1	26	June 1
OR 4920002	HR	104	61	13.5	30	June 5
IDO 377S	HR	102	61.3	13.4	39	June 4
Iona	HR	99	61.8	13.4	40	June 2
WA 7839	HR	99	59.9	13.8	37	May 29
Hank	HR	98	59.8	13.8	34	June 1
IDO 557	HR	97	60.9	14.5	35	June 1
WPB-936	HR	97	60.3	14.3	33	June 2
Scarlet	HR	91	60.2	13.6	40	June 5
Tara (WA 7824)	HR	88	60.8	14.6	40	May 30
Winsome (45 seeds/ft^2)	HW	124	60.7	11.2	35	June 4
Winsome	HW	123	60.1	11.3	35	June 6
WA 7901	HW	120	61.7	12.1	40	June 6
Winsome (20 seeds/ft^2)	HW	116	61.2	11.5	34	June 7
WA 7899	HW	113	62.5	12.4	36	June 1
Lolo (IDO 533)	HW	112	61.7	12.4	38	June 4
WA 7900	HW	111	62.8	12.6	37	June 4
Sunco	HW	109	60.7	11.9	32	June 7
IDO 560	HW	105	59.6	11.8	36	June 6
Penawawa	SW	124	61.4	11.3	37	June 7
Alpowa	SW	111	60.7	11.8	37	June 5
Mean		108	60.9	12.8	36	June 4
LSD (0.05)		14	1.4	0.8		

*HR = hard red, HW = hard white, SW = soft white.

†Adjusted to 10% moisture, 60 lb/bu.

Table 4. Spring soft white wheat yield, test weight, protein percentage, height at maturity, and date of 50 percent heading, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Variety	Market class*	Yield	Test weight	Protein	Height	Heading day
		bu/acre†	lb/bu	%	in	
WA 7902	Club	107	58.9	10.3	36	June 3
Jefferson	HR	96	64.2	11.9	37	June 2
Winsome	HW	108	62.4	11.2	36	June 6
WA 7884	SW	114	62.9	10.2	40	June 4
Challis	SW	114	61.6	9.5	37	June 1
Treasure	SW	111	62	10.1	38	June 4
IDO 526	SW	109	62.1	10.5	35	June 3
Penawawa	SW	108	63.7	10.2	36	June 2
Zak	SW	103	62.3	11.1	37	June 5
Whitebird	SW	101	61.9	10.2	39	June 4
Alpowa (untreated)	SW	101	63.6	10.6	36	June 1
Alpowa	SW	100	63.5	10.3	36	June 2
Alpowa (no Gaucho)	SW	98	63.1	10.1	37	June 2
Jubilee (IDO 525)	SW	97	62	11	38	June 3
Wawawai	SW	92	60.5	11.2	40	June 3
Rene-98	SW	84	56.7	11.7	41	June 2
Mean		103	62	10.6	37	June 3
LSD (0.05)		ns	2	1.1		

*HR = hard red, HW = hard white, SW = soft white.

†Adjusted to 10% moisture, 60 lb/bu.

Table 5. Spring barley yield, test weight, protein percentage, height at maturity, and date of 50 percent heading, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Variety	Market class*	Yield	Test weight	Protein	Height	Heading day
		lb/acre	lb/bu	%	in	
Farmington	2RF	6,000	53.5	12.7	28	June 9
Xena	2RF	4,657	55.5	12.6	34	June 9
Orca	2RF	4,577	55.1	14	34	May 27
H3860224	2RF	4,046	55.9	13.7	35	June 7
Valier	2RF	3,952	55	13.4	33	June 5
BCD-47 (Othello)	2RF/M	4,877	53.7	13.2	27	June 1
Chinook	2RM	4,310	55.9	13.8	33	June 10
Harrington	2RM	4,057	54.6	14.3	31	June 9
Garnet	2RM	4,044	55.2	13.6	30	June 6
Bancroft	2RM	3,159	55.8	14.3	29	June 7
Tango	6RF	5,097	53.4	11.6	32	May 30
Steptoe	6RF	3,155	53.1	12.8	36	May 29
Stab-113	6RF/M	5,541	54	11.3	34	June 4
Stab-7	6RF/M	4,263	49	13.1	33	June 7
Stab-47	6RF/M	4,202	53.9	13.9	36	May 29
WA 8682-96	6RF/M	3,403	55.6	13.3	35	June 8
Morex	6RM	2,891	54.4	13.8	40	May 27
Cayuse	H Oat	3,812	33.8	16.3	40	June 10
Lamont	H Oat	2,018	41.1	22.9	40	June 13
Provena	H Oat	1,940	45	23.5	39	June 10
Trial Mean		4,000	52.2	14.4	34	June 5
LSD (0.05)		979	1.4	1		

*2RF = two-row feed, 2RM = two-row malt, 2RF/M = 2-row feed or malt, 6RF = six-row feed, 6RF/M = six-row feed or malt, H Oat = hull-less oat.

WEED CONTROL AND CROP TOLERANCE WITH BRONATE® IN SPRING WHEAT AND BEYOND® IN CLEARFIELD™ SPRING WHEAT

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Introduction

Weed control is important in small grain production to reduce competition to the crop and reduce the production of weed seeds for future crops. Bronate formulations were evaluated in spring wheat. Wheat has been developed that is resistant to the imidazolinone family of chemicals (Beyond, Raptor, Pursuit), allowing Beyond herbicide to be used for weed control. The resistant wheat is marketed as Clearfield wheat. Beyond was tested in Clearfield spring wheat.

Methods

General Procedures

Two trials were conducted in the same field at the Malheur Experiment Station, one comparing Bronate rates and formulations in conventional spring wheat, the other evaluating Beyond rates with different surfactants both with and without urea ammonium nitrate (32 percent N) in Clearfield spring wheat. The soil was an Owyhee silt loam with pH 8.0 and 1.2 percent organic matter. On April 4, the wheat variety 'Alpoa' was planted in the Bronate trial area at 120 lb/acre and variety 'BZ 9M 99-1210' at 120 lb/acre was planted in the Beyond trial area. Plots for both trials were 10 ft wide by 30 ft long and replicated four times in a randomized complete block design. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer delivering 20 gal/acre at 30 psi. Percent crop injury and percent weed control were evaluated throughout the growing season. Grain yield was determined on July 24 by harvesting a swath 4.16 ft wide down the center of each plot with a Wintersteiger small plot combine.

Bronate Formulations

Bronate formulations evaluated included both a 4- and 5-lb/gal emulsifiable concentrate (EC). Both formulations were tested at rates of 0.5 and 0.75 lb ai/acre. Each Bronate formulation at the 0.5 lb ai/acre rate was tested in a tank-mix with Harmony Extra (0.014 lb ai/acre). Herbicide applications were made on May 11 to wheat that was 7 inches tall.

Beyond Rates and Additives

Beyond was applied at 0.024 and 0.032 lb ai/acre. Each Beyond rate was tested with a non-ionic surfactant (NIS) at 0.25 percent v/v both with and without 32 percent N at 2.5 percent v/v, and SUN-IT II surfactant at 1.0 percent v/v both with and without 32 percent N. Beyond was applied to 7-inch-tall wheat on May 11.

Results

Bronate Formulations

Thirteen days after applications were made, there was no visible injury to the crop (Table 1).

All treatments provided excellent common lambsquarters and shepherdspurse control throughout the growing season (91-98 percent). On May 24, both Bronate formulations at the 0.5 lb ai/acre rate were among the weakest in common lambsquarters control (92-93 percent). All treatments were significantly better at controlling shepherdspurse than Bronate 5 EC at the 0.5 lb ai/acre rate. By July 23, all treatments provided significantly better common lambsquarters control than Bronate 5 EC at 0.5 lb ai/acre.

Possibly due to low weed populations and an absence of crop injury by any of the herbicide treatments, there were no differences in yield between any of the treatments and the untreated check.

Beyond Rates and Additives

On May 24, Beyond at the 0.032 lb ai/acre rate with either NIS plus 32 percent N or SUN-IT II plus 32 percent N gave injury significantly greater then the check (14 and 29 percent, respectively) (Table 2).

All Beyond treatments were weak on common lambsquarters control providing only 30-58 percent control throughout the season. On May 24, Beyond at 0.032 lb ai/acre plus SUN-IT II and 32 percent N resulted in significantly better common lambsquarters control than Beyond at either 0.024 or 0.032 lb ai/acre rates plus NIS only. On July 23, Beyond at 0.024 lb ai/acre plus NIS continued to be among the weakest in common lambsquarters control with Beyond at 0.024 lb ai/acre plus SUN-IT II and Beyond at 0.032 lb ai/acre with either SUN-IT II alone, or SUN-IT II plus 32 percent N, or NIS plus 32 percent N being significantly better.

There were no differences in grain yield between any treatments including the untreated check.

Table 1. Crop Injury, weed control, and grain yield with Bronate formulations and rates, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

			Weed control			
			Common lambsquarters		Shepherds-purse	
Treatment*	Rate	Crop injury†	5-24	7-23	5-24	Wheat yield‡
	lb ai/acre	%	----------------------	%	----------------------	bu/acre
Bronate 4 EC	0.5	0	93	96	97	106
Bronate 5 EC	0.5	0	92	91	92	102
Bronate 4 EC	0.75	0	97	98	97	99
Bronate 5 EC	0.75	0	98	98	98	100
Bronate 4 EC + Harmony Extra	0.5 0.014	0	95	97	97	102
Bronate 5 EC + Harmony Extra	0.5 0.014	0	94	95	97	102
Untreated	--	0	0	0	0	95
LSD (0.05)		0	4	4	4	NS

*Applications were made May 11 to 7-inch wheat.
†Crop injury ratings taken on May 24.
‡Wheat harvested on July 24.

Table 2. Crop injury, weed control, and grain yield with Beyond in Clearfield wheat, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

Treatment*	Rate	Crop injury†	Weed control: Common lambsquarters 5-24	Weed control: Common lambsquarters 7-23	Wheat yield‡
	lb ai/acre	%	%	%	bu/acre
Beyond + NIS + 32% N	0.024	6	44	42	73
Beyond + NIS	0.024	0	30	32	70
Beyond + SUN-IT II + 32% N	0.024	6	45	43	75
Beyond + SUN-IT II	0.024	1	50	47	70
Beyond + NIS + 32% N	0.032	14	53	49	76
Beyond + NIS	0.032	3	41	42	78
Beyond + SUN-IT II + 32% N	0.032	29	58	54	72
Beyond + SUN-IT II	0.032	5	48	47	77
Untreated	--	0	0	0	85
LSD (0.05)		9	16	13	NS

*Applications were made May 11 to 7-inch tall wheat.
†Crop injury ratings taken on May 24.
‡Wheat harvested on July 24.

ROTATIONAL CROP RESPONSE TO WHEAT HERBICIDE CARRYOVER

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Introduction

Herbicide carryover can restrict crop rotation following application of soil residual herbicides in the previous year(s). Rotational restrictions following herbicide application vary depending upon the herbicide used, rotational crop, and various environmental factors influencing the duration of herbicide soil persistence at or above injurious levels. In this study several crops were evaluated for their rotational response to the experimental herbicide BAS 635 00H, as well as the registered herbicides Paramount and Ally.

Methods

A trial was established at the Malheur Experiment Station to evaluate BAS 635 00H, Paramount, and Ally herbicides for rotational crop injury following postemergence application to spring wheat in the previous year. The soil type for the trial was an Owyhee silt loam having an organic matter content of 1.4 percent, a pH of 7.7, and a cation exchange capacity of 15 meq/100 g of soil. Experimental plots measured 24 ft by 60 ft and were arranged in a randomized complete block with three replicates. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi.

Spring wheat (var. 'Penawawa') was seeded at a rate of 120 lbs/acre on April 15, 2000. Herbicides were applied postemergence to spring wheat on May 15, 2000. BAS 635 00H was applied at rates of 0.054, 0.108, and 0.162 lb ai/acre. Paramount application rates were 0.188, 0.375, and 0.56 lb ai/acre. Application rates for Ally were 0.004, 0.008, and 0.012 lb ai/acre. Both BAS 635 00H and Ally were applied with a non-ionic surfactant (NIS) applied at 0.25 percent v/v. Paramount was applied with a methylated seed oil (MSO) at a rate of 1.5 percent v/v.

The rotational crops evaluated were alfalfa, dry beans, potato, sugar beet, and wheat. Rotational crops were planted across the width of the herbicide treatments. Alfalfa (var. 'Rustler II') was planted at 25 lbs/acre on April 20. Pinto beans (var. 'Othello') were planted on May 21 using a two-inch seed spacing. 'Russet burbank' potatoes were planted using a 9-inch spacing on April 18. Sugar beets (var. 'PM-21') were planted on April 20 using a 2-inch spacing. Spring wheat (var. 'Alpowa') was planted at 120 lbs/acre on April 19. Injury evaluations were taken throughout the growing season. Yield data was collected for alfalfa on July 2 and August 9, wheat on August 6, pinto beans on August 20, potatoes on September 9, and sugar beets on October 3. Data were analyzed using ANOVA, and treatment means were separated using Fishers protected LSD (0.05).

Results

Crop injury from residual herbicide treatments was not apparent for alfalfa or wheat on May 18 or at any point during the growing season (Table 1). Injury to pinto beans was greatest with Paramount treatments ranging from 24 to 28 percent on July 2. Significant potato injury was observed on both May 22 and July 2 in plots treated with Paramount. Injury in these plots ranged from 21 to 45 percent. Paramount injury to both dry beans and potatoes was characterized by growth regulator-type injury such as leaf crinkling and leaf cupping. On May 18, sugar beet injury was apparent in all treated plots and ranged from 9 to 56 percent. The greatest sugar beet injury was in plots treated with BAS 635 00H (0.162 lb ai/acre), and those treated with Ally at both 0.008 and 0.012 lb ai/acre. BAS 635 00H (0.162 lb ai/acre) injured sugar beets 37 and 24 percent on May 18 and July 2, respectively. BAS 635 00H applied at 0.162 lb ai/acre produced significantly greater injury than when applied at 0.054 lb ai/acre. Ally applied at 0.012 and 0.008 lb ai/acre injured sugar beets 26 and 28 percent greater on May 18 and 20 and 22 percent greater on July 2 than Ally applied at 0.004 lb ai/acre. On July 2, Paramount applied at 0.375 lb ai/acre was the only Paramount treatment that produced injury significantly greater than the untreated check.

There were no differences in yield among treatments for alfalfa, spring wheat, and pinto beans (Table 2). None of the herbicide treatments significantly reduced potato yields compared to the untreated check. Despite potato injury from Paramount soil residual activity, only Paramount applied at 0.375 lb ai/acre provided potato yields lower than the untreated check. Potato yields in plots treated with Ally were from 109 to 125 percent of the untreated check. In plots treated with BAS 665 00H potato yields ranged from 116 to 126 percent of the untreated yield. Overall, sugar beet yields were lower in plots treated with Ally. Yields were 87, 84, and 75 percent of the untreated check for Ally applied at 0.004, 0.008, and 0.012 lb ai/acre, respectively. Sugar beet yields with BAS 635 00H were 92 to 99 percent of the untreated and yields with Paramount were 97 to 102 percent of the untreated check.

Table 1. Rotational crop injury with BAS 635 00H, Paramount, and Ally, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

		Rotational crop injury[†]						
		Alfalfa	Wheat	Dry bean	Potato		Sugar beet	
Treatment*	Rate	5-18	5-18	7-2	5-22	7-2	5-18	7-2
	lb ai/acre	%						
BAS 635 00H + NIS	0.054 + 0.25% v/v	0	0	2	0	0	9	0
BAS 635 00H + NIS	0.108 + 0.25% v/v	0	0	0	0	0	24	8
BAS 635 00H + NIS	0.162 + 0.25% v/v	0	0	2	0	0	37	24
Paramount + MSO	0.188 + 1.5% v/v	0	0	28	21	22	13	10
Paramount + MSO	0.375 + 1.5% v/v	0	0	24	37	28	17	20
Paramount + MSO	0.56 + 1.5% v/v	0	0	25	45	35	14	13
Ally + NIS	0.004 + 0.25% v/v	0	0	7	0	0	28	20
Ally + NIS	0.008 + 0.25% v/v	0	0	3	0	0	56	42
Ally + NIS	0.012 + 0.25% v/v	0	0	7	2	0	54	40
Untreated	--	0	0	0	0	0	0	8
LSD (0.05)		NS	NS	10	25	16	22	19

*Treatments were applied to wheat on May 15, 2000.
[†]Crop injury was based on visual evaluations using a scale from 0 percent (no injury) to 100 percent (plant death).

Table 2. Rotational crop yield as a percent of the untreated with BAS 635 00H, Paramount, and Ally, Malheur Experiment Station, Oregon State University, Ontario, OR, 2001.

		Rotational crop yield[†]					
		Alfalfa[‡] (fresh wt)		Wheat	Potato	Sugar beet	Dry bean
Treatment*	Rate	7-2	8-9	8-6	9-4	10-3	8-20
	lb ai/acre	% of untreated[§]					
BAS 635 00H + NIS	0.054 + 0.25% v/v	89	97	109	126	99	78
BAS 635 00H + NIS	0.108 + 0.25% v/v	98	95	116	126	96	79
BAS 635 00H + NIS	0.162 + 0.25% v/v	92	96	115	116	92	85
Paramount + MSO	0.188 + 1.5% v/v	102	97	119	124	102	72
Paramount + MSO	0.375 + 1.5% v/v	109	99	127	94	97	99
Paramount + MSO	0.56 + 1.5% v/v	98	96	131	104	101	100
Ally + NIS	0.004 + 0.25% v/v	119	93	123	109	87	103
Ally + NIS	0.008 + 0.25% v/v	97	94	113	119	84	73
Ally + NIS	0.012 + 0.25% v/v	117	89	107	125	75	104
Untreated	--	100	100	100	100	100	100
LSD (0.05)		NS	NS	NS	21	13	NS

*Treatments were applied to previous wheat crop on May 15, 2000.
[†]Yield for rotational crops produced following herbicide application in the previous growing season.
[‡]Alfalfa fresh weight taken immediately after cutting. Yields shown for both the July 2 and August 9 harvest dates.
[§]Yields are reported as a percentage of the untreated for each crop.

EVALUATION OF THE AM400 SOIL MOISTURE DATA LOGGER TO AID IRRIGATION SCHEDULING

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Summary

Growers need easy and convenient ways to monitor soil moisture status to improve their irrigation scheduling. We examined the AM400 Soil Moisture Data Logger with Graphic Display (M.K. Hansen Co., East Wenatchee, WA) to see if it would aid irrigation scheduling using data from Watermark Soil Moisture Sensors (Irrometer Co., Inc., Riverside, CA). For simplicity, we refer to the AM400 Soil Moisture Data Logger with Graphic Display, as "Hansen unit". Each Hansen unit was wired to six Watermark Soil Moisture Sensors and one temperature probe. Hansen units were installed in 14 crop fields as aids to irrigation scheduling during the 2000 season. The practical usefulness of the loggers and their data are presented.

Introduction

Crop yields and quality in Malheur County Oregon are directly related to the quality of irrigation management. Watermark Soil Moisture Sensors have been used for managing soil water in potatoes and irrigation scheduling by growers in Malheur County since the late 1980's and that use has expanded to onions and other crops. We have shown that onion yield and grade and the growth of poplar trees are closely related to irrigation scheduling and maintenance of soil water potential (SWP) within narrow bounds.

Watermark readings have been recorded manually with a 30 KTCD meter (Irrometer Co., Inc., Riverside, CA) , transferred to computer files, and graphed manually or by computer to demonstrate whether the SWP was wetter or drier than the irrigation criteria for the particular crop. It is easier for the grower to see the SWP in graphical form, because the relative position (wet or dry) is clearer and the rate of drying over time makes more sense as a graph. Hansen units were tested for ease of interpretation for irrigation scheduling at the Malheur Experiment Station and in growers' fields.

Materials and Methods

Set up in 2000

Six granular matrix sensors (GMS, Watermark Soil Moisture Sensors, (Irrometer Co., Inc., Riverside, CA) were installed at 10- or 12-inch depth (depth to the bottom of the sensor) in the crop rows in 14 fields (Table 1). The GMS were installed directly in the center of the crop rows for furrow-irrigated and drip-irrigated onions and sugar beets. For potatoes, the sensors were located at 10-inch depth, and between two plants, 4 inches off of the center of the hill. Sensors were installed with the aid of a 7/8-inch-diameter soil probe. The sensor was pressed to the bottom of the soil probe hole with an insertion wire, 2 oz of water were poured into the hole, soil was gently packed above the sensor, and the soil left level with little trace of installation except the wires coming out of the soil.

An additional 50 to 125 ft of wire was added to each of the GMS before installation and attachment to the Hansen units. This extra wire allowed the grower to spread the sensors over a wider area of the field. Insulation was stripped off of the GMS wire and the GMS was connected to an 18-gauge wire using a butt connector adapter (4*260-5,3M Highland) and shrink tubing, (3KH56-7, W.W. Grainger). The other end of the wire was connected to the Hansen unit. Six GMS and one temperature probe were connected to the Hansen unit starting at the double portal reading no. 1 and finally the temperature probe was connected to portal no. 7.

The Hansen units were mounted on 4- by 6-inch posts, and set facing to the north. The posts themselves were placed in an area that was judged to be representative of the entire field.

Results and Discussion

The SWP from sample fields is presented below. The SWP irrigation criteria for alfalfa forage on silt loam is in the range of -60 kPa. Regular use of sensor readings allowed the average SWP to remain within the ideal range most of the time (Fig. 1). The frequency of irrigation depended on the weather and the stage of growth of the alfalfa.

The SWP criteria for drip-irrigated onions on silt loam is in the vicinity of -20 kPa. This criteria was rather carefully followed in a grower's drip-irrigated onion field (Fig. 2). The crop was maintained too wet at the beginning and end of the season.

The irrigation criteria for furrow- or sprinkler-irrigated potatoes on Malheur County silt loam is -50 to -60 kPa. This criteria can be closely followed (Fig. 3), but notice that at the end of the season the crop was irrigated before it reached its criteria. This systematic irrigation error resulted in tuber decomposition before harvest.

The use of drip irrigation for sugar beets is entirely experimental. No irrigation criteria has been established (Fig. 4). If the criteria is in the range of -30 to -40 kPa, the crop was maintained too wet.

Reading for Irrigation Scheduling

Since the Watermarks are already wired to the Hansen unit, the reading of the sensors is very rapid. The outside cover was removed, and the red button, located in the center of the unit, was pressed. After the button is pressed, the screen will show the data for Watermark sensor no. 1, including the temperature and the SWP in centibars or kilo

Pascals (1 cbar = 1 kPa). Data from the last 5 weeks is displayed on the screen. The most recent logged data is on the right side of the screen. The lower the point is on the screen, the drier the soil.

Take careful note of the left hand side of the screen. The magnitude of the scale changes with the range of the data.

To read the graphs and instantaneous data for the other five Watermark sensors, continue to press the red button; each sensor is read in turn. When all the sensor have been scrolled through, replace the cover. The unit will turn itself off.

If you wish to collect all the data for a season, the data can be collected using a laptop computer or palm pilot. For instructions for use of a palm pilot please see http://www.cropinfo.net/downloads/soilwater.html.

Table 1. Hansen units were installed in 14 crop fields during the 2000 crop season. Malheur Experiment Station, Oregon State University, Ontario, OR.

Crop	Irrigation system	Location	Depth to the bottom of the 5 or 6 shallow sensors	Depth to the bottom of the single deep sensor
			---inches---	---inches---
1. Alfalfa	Sprinkler	MES Field B2	12	NA
2. Alfalfa	Sprinkler	MES Field A2	12	NA
3. Potatoes	Furrow	MES Field D-1a	10	NA
4. Onions	Drip	Skyline Farms	10	14
5. Potatoes	Sprinkler	Gressley Farms	10	14
6. Onions	Furrow	MES B-8b	10	14
7. Wheat	Drip	Ontario Farms	10	NA
8. Sugar beets	Furrow	MES B-8a	10	14
9. Potatoes	Furrow	MES D-1a	10	14
10. Onions	Drip	Ontario Farms	10	14
11. Sugar beets	Drip	Ontario Farms	10	14
12. Potatoes	Sprinkler	Teramura Farms	10	14
13. Onions	Drip	Komoto Farms	10	14
14. Onions	Drip	DeBoer Farms	10	14

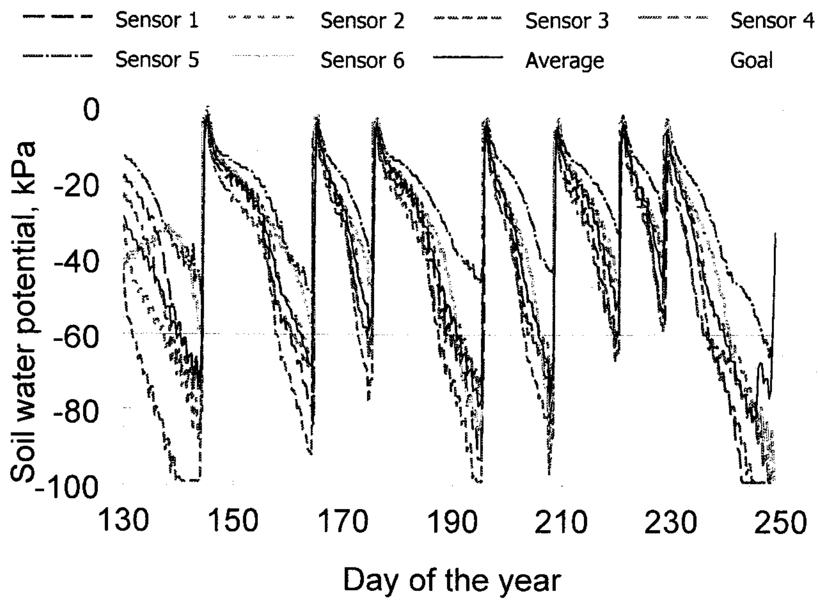

Figure 1. Soil water potential at 12-inch depth in sprinkler-irrigated alfalfa as measured by 6 GMS and recorded by a Hansen unit, Malheur Experiment Station, Oregon State University, Ontario, OR 2000.

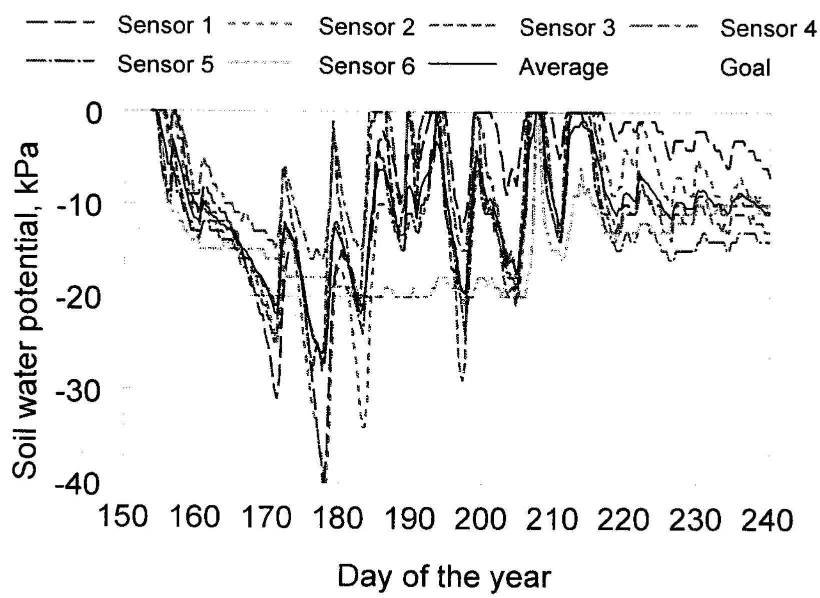

Figure 2. Soil water potential at 10-inch depth in drip-irrigated onions as measured by 6 GMS and recorded by a Hansen unit in a grower's field, Malheur Experiment Station, Oregon State University, Ontario, OR 2000.

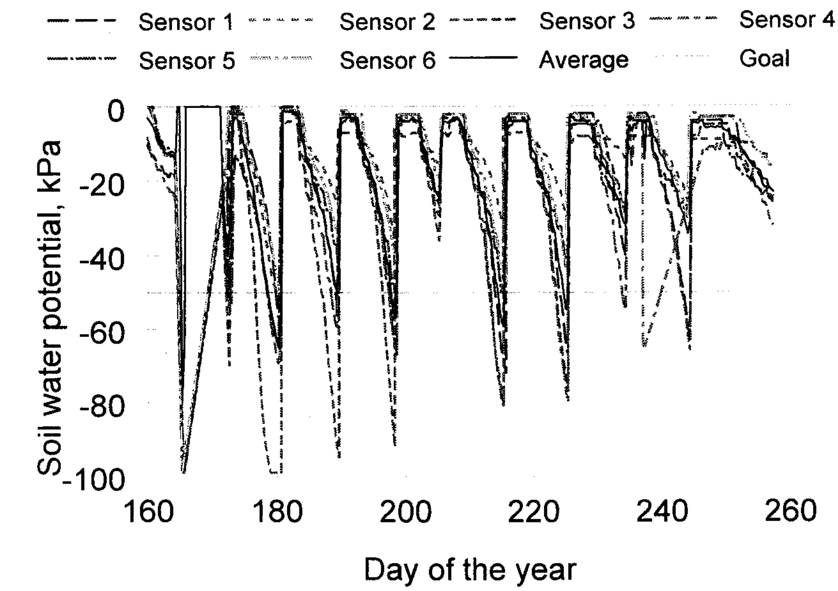

Figure 3. Soil water potential at 10-inch depth in a furrow-irrigated potato field as measured by 6 GMS and recorded by a Hansen unit, Malheur Experiment Station, Oregon State University, Ontario, OR 2000.

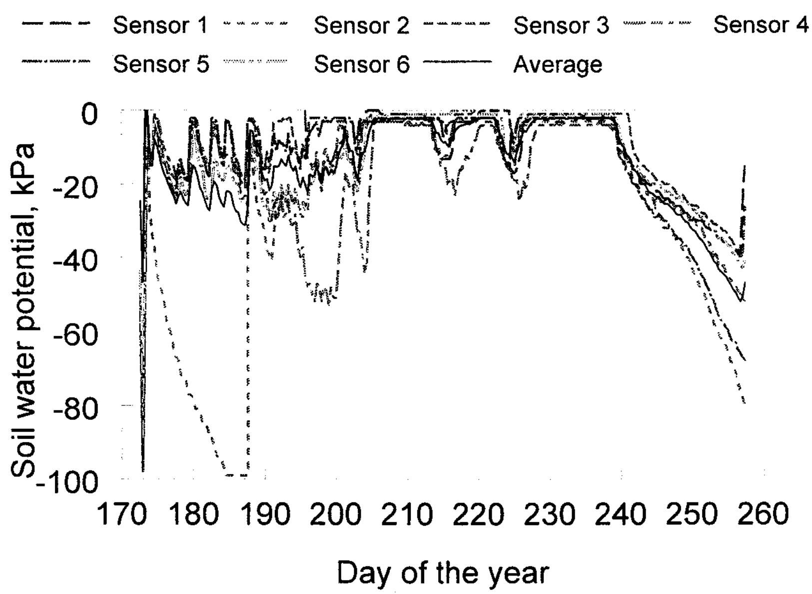

Figure 4. Soil water potential at 10-inch depth in drip-irrigated sugar beets as measured by 6 GMS and recorded by a Hansen unit in a grower's field, Malheur Experiment Station, Oregon State University, Ontario, OR 2000.

IRRIGATION SCHEDULING IN LONG-TERM BURIED DRIP

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Summary

Trials were initiated to demonstrate the continuous use of drip tape from a single installation through one or more complete crop rotations. Tape was buried 9 inches deep, where a sequence of crops could be planted to establish the viability of long term use of tape in the same field without removal. Onions, wheat, and sugar beets are being grown in rotation in successive years on 3-acre plots. Mint is being grown on an additional 3 acres with long-term subsurface drip-irrigation (SDI). These plots have been established and are being monitored at Ontario Farms, Ontario in cooperation with David Blaylock.

Introduction

Until recently, all drip irrigation installations in Malheur County have been for only one season. After the end of the season the drip tape has been removed and discarded. The current trial seeks to produce a sequence of crops using the same drip tape.

Permanent drip plots at Ontario Farms from north to south are as follows:

Plot 1, 3.32 acres, mint in 2001, mint in 2000;

Plot 2, 3.34 acres, wheat in 2001, sugar beets in 2000;

Plot 3, 3.35 acres, onion in 2001, wheat in 2000;

Plot 4 3.37 acres, sugar beets in 2001, onions in 2000.

Watermark Soil Moisture Sensors have been used for managing soil water in potatoes and irrigation scheduling by growers in Malheur County since the late 1980's and that use has expanded to onions and other crops. We have shown that onion yield and grade (Shock et al. 2000) and the growth of poplar trees (Shock et al. 2002) are closely related to irrigation scheduling and maintenance of soil water potential (SWP) within narrow bounds.

Watermark readings have been recorded manually with a 30 KTCD meter (Irrometer Co., Inc., Riverside, CA), transferred to computer files, and graphed manually or by computer to demonstrate whether the SWP was wetter or drier than the irrigation criteria for the particular crop. It is easier for the grower to see the SWP in graphical form, because the relative position (wet or dry) is clearer and the rate of drying over time makes more sense as a graph.

Soil moisture data loggers with graphic displays (AM400 Soil Moisture Data Logger with Graphic Display (M.K. Hansen Co., East Wenatchee, WA) "Hansen units" were tested for ease of interpretation for irrigation scheduling at the Malheur Experiment Station and in growers' fields.

Materials and Methods

Soil Moisture Monitoring in 2001

Six granular matrix sensors (GMS, Watermark Soil Moisture Sensors, Irrometer Co., Inc., Riverside, CA) were installed at 8-inch depth (depth to the bottom of the sensor) in mint, onion, and sugar beet fields. The GMS were installed directly in the center of the crop rows. Sensors were installed with the aid of a 7/8-inch-diameter soil probe. Each sensor was pressed to the bottom of the soil probe hole with an insertion wire, 2 oz of water were poured into the hole, soil was gently packed above the sensor, and the soil was left level with little trace of installation except the wires coming out of the soil.

An additional 50 to 125 ft of wire was added to each of the GMS before installation and attachment to the Hansen units. This extra wire allowed the grower to spread the sensors over a wider area of the field. Insulation was stripped off of the GMS wire and the GMS was connected to 18-gauge wire using a butt connector adapter (4*260-5,3M Highland) and shrink tubing (3KH56-7, W.W. Grainger). The other end of the wire was connected to the Hansen unit. Six GMS and one temperature probe were connected to the Hansen unit starting at the double portal reading no. 1 and finally the temperature probe was connected to portal no. 7.

The Hansen units were mounted on 4- by 6-inch posts, and set facing to the north. The posts themselves were placed in an area that was judged to be representative of the entire field.

Results and Discussion

Mint

The SWP was readily maintained very wet in the permanent drip-irrigated plot containing mint (Fig. 1). It is difficult to interpret the soil water management because an ideal SWP criteria has not been established for mint. The field may have been too wet during June from June 12 through June 26 (day 163 through day 177). In late July the field was intentionally allowed to dry for harvest. The abrupt drop in SWP starting in mid-August (day 225) is a reflection of the end of the irrigation season.

Onions

Ideal SWP for drip-irrigated onions is known to be -20 kPa (Shock et al. 2000). Although the surface of the soil appeared rather dry, the field remained wet all season in the onion root zone (Fig. 2). During June (through day 180) the soil remained excessively wet in spite of the appearance of being too dry on the surface. Prolonged periods of very wet soil are conducive to the loss of soil available N and N fertilizer by denitrification and leaching losses. Consequently, it is possible that the onions in this field suffered from N deficiency. The abrupt drop in SWP starting in mid-August (day 224) is a reflection of the end of the irrigation season.

Sugar beets

It is difficult to interpret the soil water management because an ideal SWP criteria has not been established for sugar beets, but the ideal may be in the range of -40 kPa. Most probably the field was irrigated fairly close to the ideal through mid July (Fig. 3). The remainder of the irrigation season the soil remained close to saturation.

The experience from these trials points out a difficulty in scheduling irrigations with permanent buried drip. The surface of the soil may not appear to be wet, even immediately following an irrigation. Irrigation scheduling based on experience is an inadequate guide. The data available from the visual displays on the Hansen units was not integrated into the irrigation decision making.

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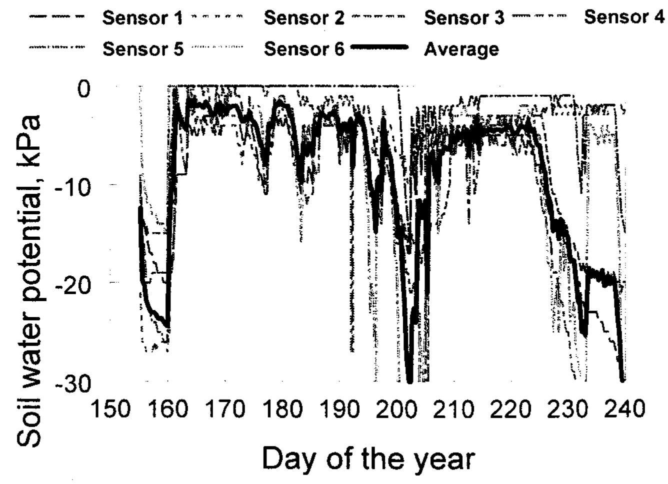

Figure 1. Soil water potential at 8-inch depth in mint with permanently buried drip tape as measured by six GMS recorded by a Hansen unit on Ontario Farms, Malheur Experiment Station, Oregon State University, Ontario, OR 2001.

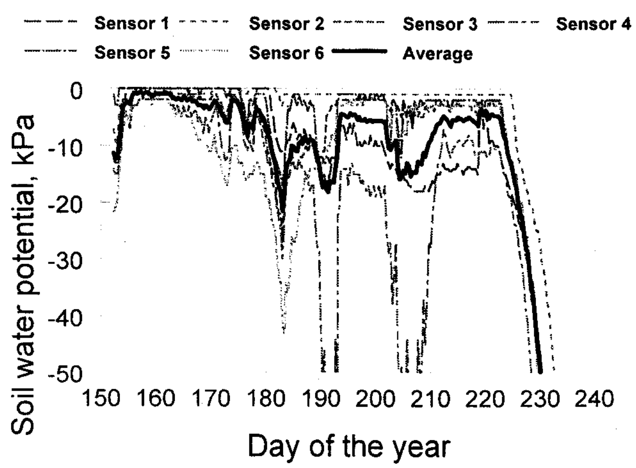

Figure 2. Soil water potential at 8-inch depth in onions with permanently buried drip tape as measured by six GMS recorded by a Hansen unit at Ontario Farms, Malheur Experiment Station, Oregon State University, Ontario, OR 2001.

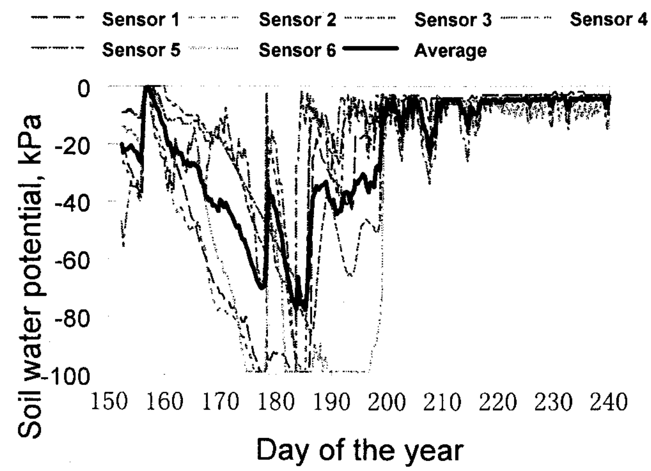

Figure 3. Soil water potential at 8-inch depth in sugar beets with permanently buried drip tape as measured by six GMS recorded by a Hansen unit on Ontario Farms, Malheur Experiment Station, Oregon State University, Ontario, OR 2001.

A COMPARISON OF SIX SOIL MOISTURE SENSORS

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Introduction

Six soil moisture sensors were compared by their performance in producing soil moisture data in an irrigated hybrid poplar plantation.

Materials and Methods

The sensor comparison study was done in a microsprinkler-irrigated hybrid poplar tree field at the Malheur Experiment Station in Ontario, Oregon. The trees were planted in April 1997 on silt loam soil on a 14-ft by 14-ft spacing. The tree rows are oriented to the northwest. The trees are irrigated using a microsprinkler system (R-5, Nelson Irrigation, Walla Walla, WA) 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. Two inches of water were applied whenever the soil water potential at 8-inch depth reached -50 kPa. Soil water potential was measured by two granular matrix sensors (GMS) (Watermark Soil Moisture Sensors model 200SS; Irrometer Co. Inc., Riverside, CA); at 8-inch depth. The GMS were installed along the middle row and between the riser and the tree. The GMS were previously calibrated (Shock et al. 1998) and were read at 8:00 a.m. daily with a 30 KTCD-NL meter (Irrometer Co. Inc., Riverside, CA).

Two Aquaflex sensors (Streat Instruments, Christchurch, New Zealand) were installed on September 14, 2000. Each sensor was installed at 8-inch depth along the tree row and between two trees. The two Aquaflex sensors were connected to an Aquaflex datalogger. On July 23, 2001, six types of soil moisture sensors were added to the study. One sensor of each type was installed in four groups adjacent to the existing Aquaflex sensors. The position of each sensor was randomized between groups. The sensors in each group were installed in a line parallel to and approximately 8 inches from the Aquaflex sensors. The sensors were installed at 8-inch depth. Each Aquaflex sensor had a group of sensors on each side. The sensors added to the study were Tensiometer (Irrometer Co. Inc., Riverside, CA), Watermark sensor model 200SS (Irrometer Co. Inc., Riverside, CA), Neutron Probe model 503 DR hydroprobe (Boart Longyear, Martinez, CA), Moisture Point (Environmental Sensors Inc., Escondido, CA), Gro Point (Environmental Sensors Inc., Escondido, CA), and Gopher (Cooroy, Queensland, Australia). The four Gro Point sensors were connected to two Gro Point 3 channel dataloggers. The Watermark sensors were connected to an AM400 Soil Moisture Data Logger (M.K. Hansen Co., East Wenatchee, WA). All other sensors were read manually at 9:00 a.m. from Monday through Friday. The tensiometers and

Watermark sensors measure soil water potential. The other sensors use various techniques to measure volumetric soil water content.

The tensiometer and Watermark sensors required a hole made with a standard soil auger for installation. The tensiometers required regular resetting due to the column of water breaking suction around 60 to 70 kPa. The Gro Point sensor is relatively compact and was easy to bury. The neutron probe and the gopher required the installation of PVC access tubes for each location to be monitored. The Moisture Point uses a 3-ft probe permanently installed at each location to be monitored. The Moisture Point probe required a hole made with a probe provided by the company for installation. The neutron probe, Gopher, and Moisture Point allow measurement of soil moisture at different depths at each location. The aquaflex is 10 ft long and is installed horizontally, requiring a 10-ft trench dug to the depth of installation.

The neutron probe and gopher require calibration. One undisturbed core soil sample was taken in each sensor group during sensor installation. The soil samples were immediately placed in tin cans and weighed, then oven dried at 100°C for 48 hours and weighed again. Volumetric soil moisture content was calculated for the soil samples using the gravimetric method. After the sensors were installed, 2 inches of water was applied. On July 25, another set of soil samples was taken and volumetric soil moisture content was determined as before. The sensors were read at the same time as the soil samples were taken. The neutron probe was read as counts during 32 seconds. The volumetric soil water content determined from the soil samples was regressed against the neutron probe and gopher readings. The coefficient of determination (r^2) for the regression equation for the neutron probe was 0.93 at $P = 0.01$ (Fig. 1). The regression equation was used to transform the neutron probe readings to volumetric water content. A calibration for the Gopher sensor was not possible due to a lack of correlation between the gopher readings and the volumetric soil water content determined from the soil samples. The average soil moisture data from the neutron probe and from the tensiometers was regressed against the average soil moisture data for each of the other sensors.

Results and Discussion

All sensors showed good correlations ($r^2 > 0.5$) with the neutron probe and the tensiometer except the Moisture Point sensor (Figs. 2 and 3). The Aquaflex sensor produced data in a much smaller range and lower than the neutron probe data. The Moisture Point data were substantially lower than the neutron probe data (Figs. 2 and 3). The tensiometer, Watermark sensor, neutron probe, and Gro Point sensor responded well to the wetting and drying cycles of the soil (Fig. 3). The Aquaflex sensor did not respond to the wetting and drying cycles of the soil.

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.

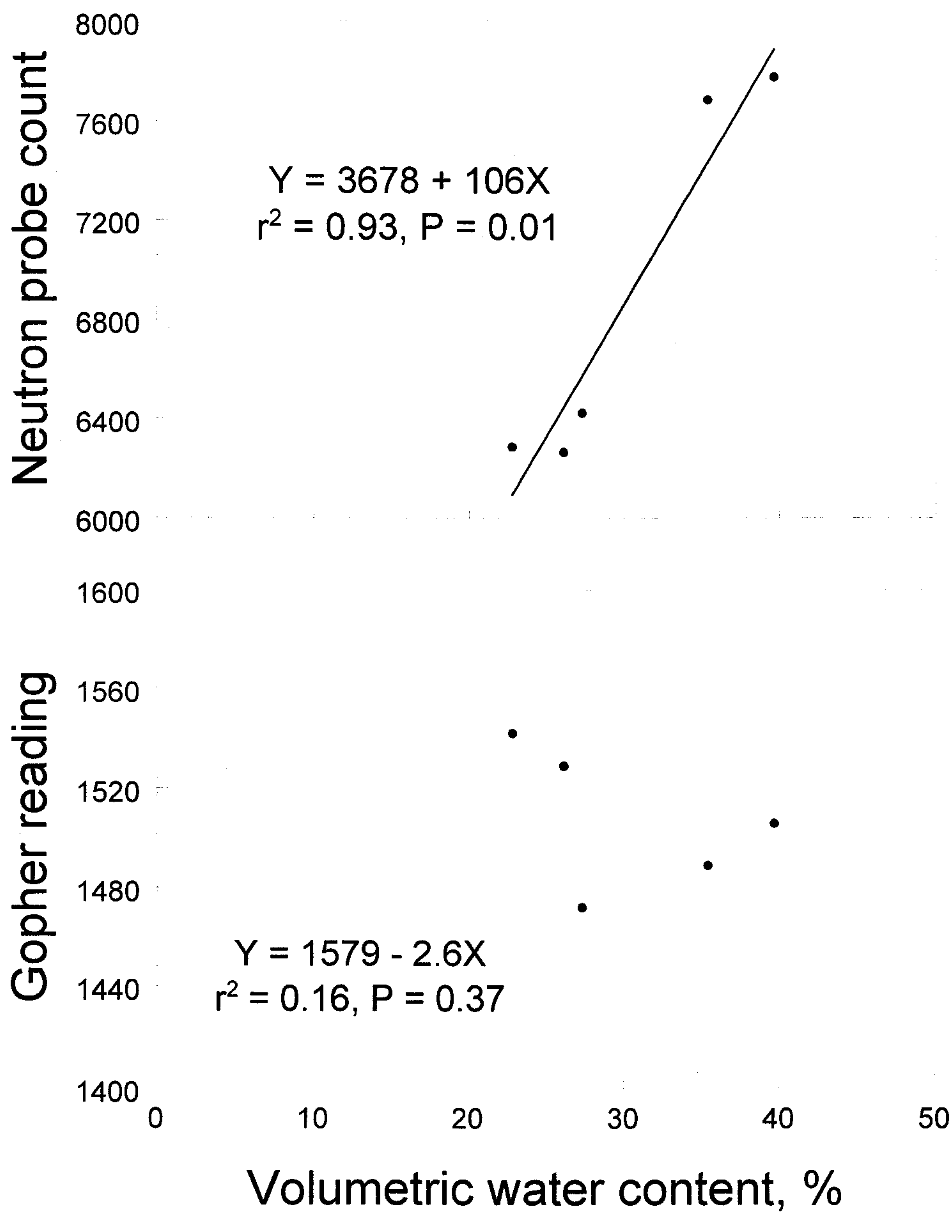

Figure 1. Regressions for calibration of the neutron probe and Gopher sensor to volumetric soil water content determined gravimetrically. Malheur Experiment Station, Oregon State University, Ontario, OR.

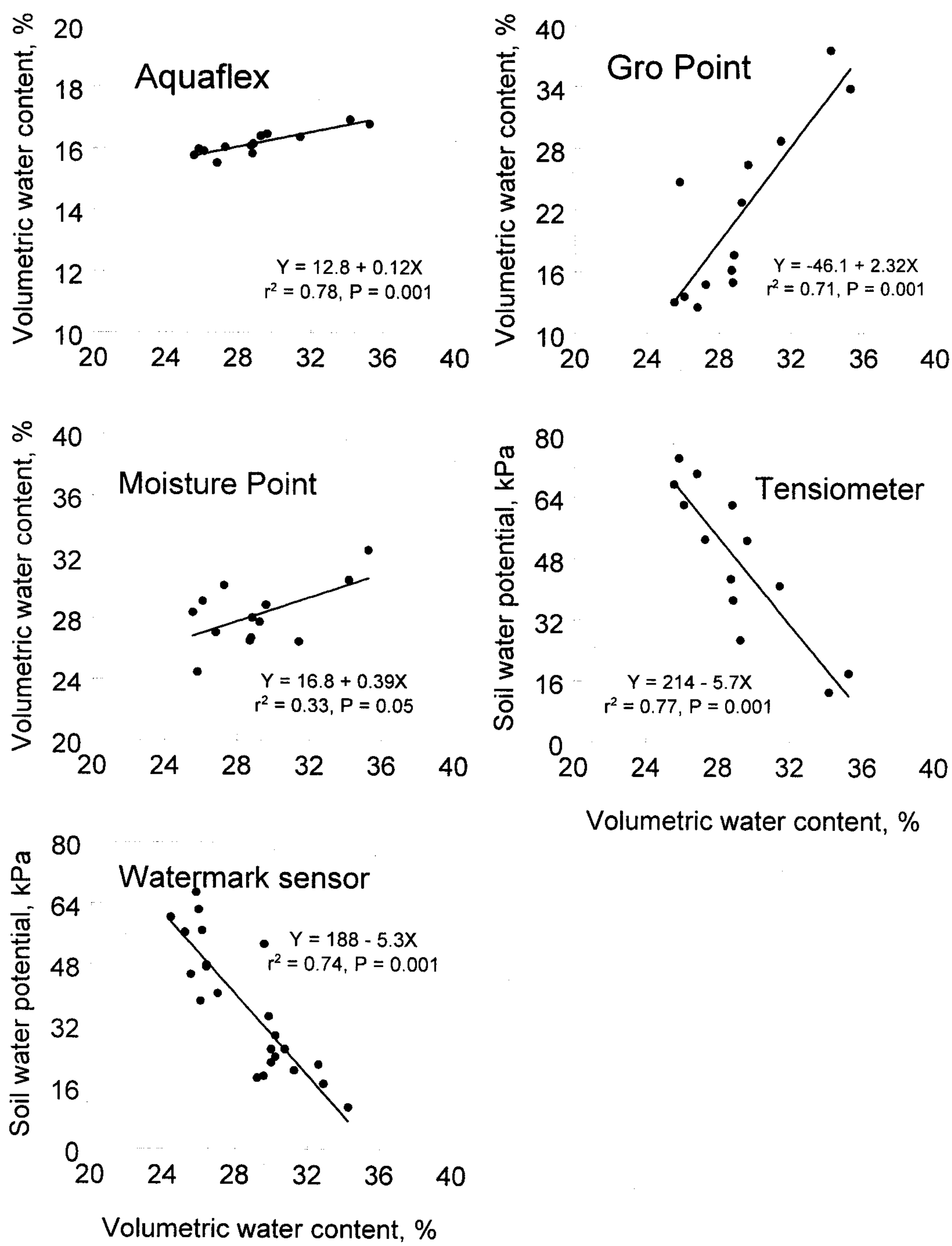

Figure 2. Volumetric soil water content measured by a neutron probe (X axis) regressed against soil moisture data (Y axis) measured by 5 types of soil moisture sensors. Data points for the Aquaflex sensor are the average of two sensors. Data points for the other sensors are the average of four sensors. Malheur Experiment Station, Oregon State University, Ontario, OR.

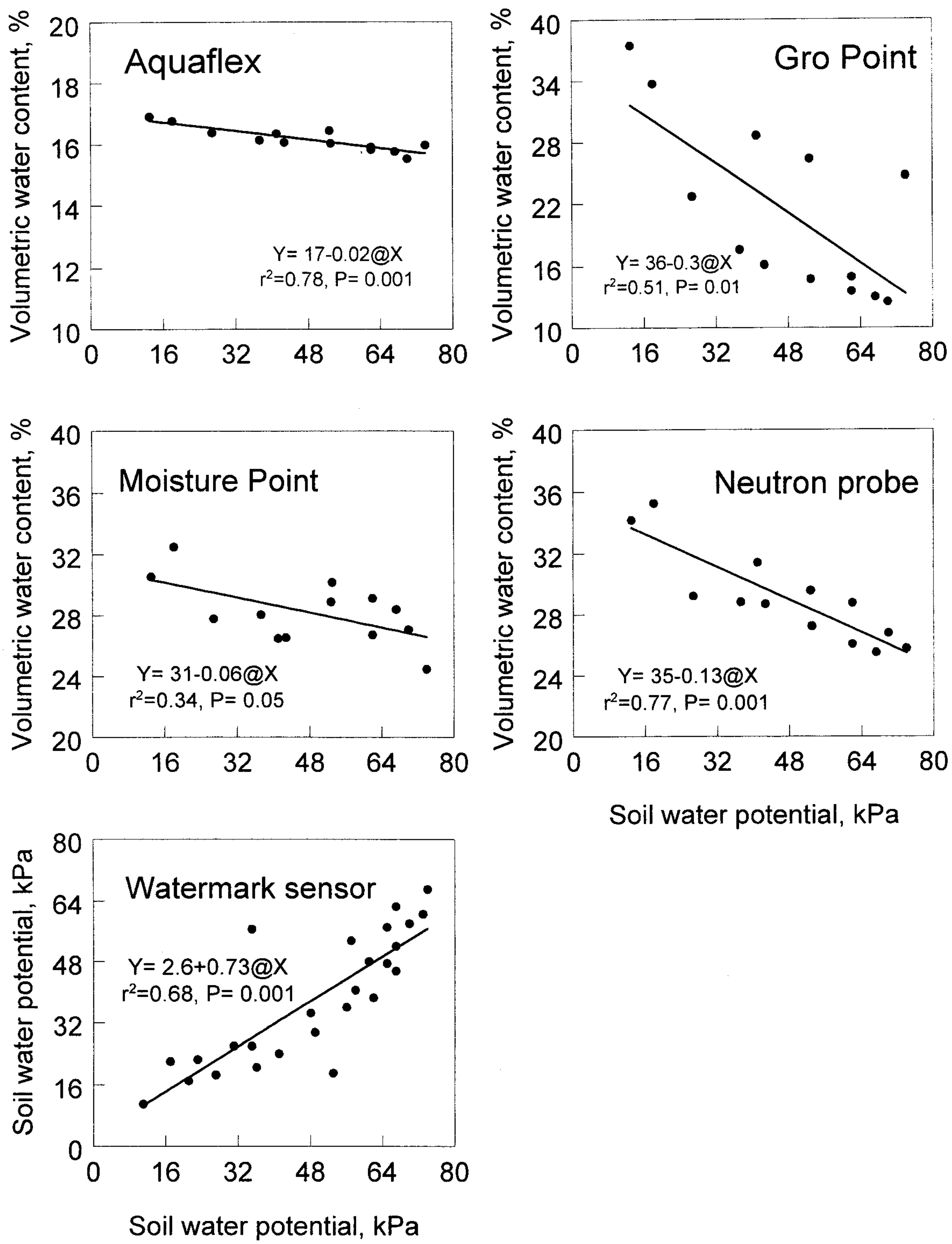

Figure 3. Soil water potential measured by tensiometers (X axis) regressed against soil moisture data (Y axis) measured by 5 types of soil moisture sensors. Data points for the Aquaflex sensor are the average of two sensors. Data points for the other sensors are the average of four sensors. Malheur Experiment Station, Oregon State University, Ontario, OR.

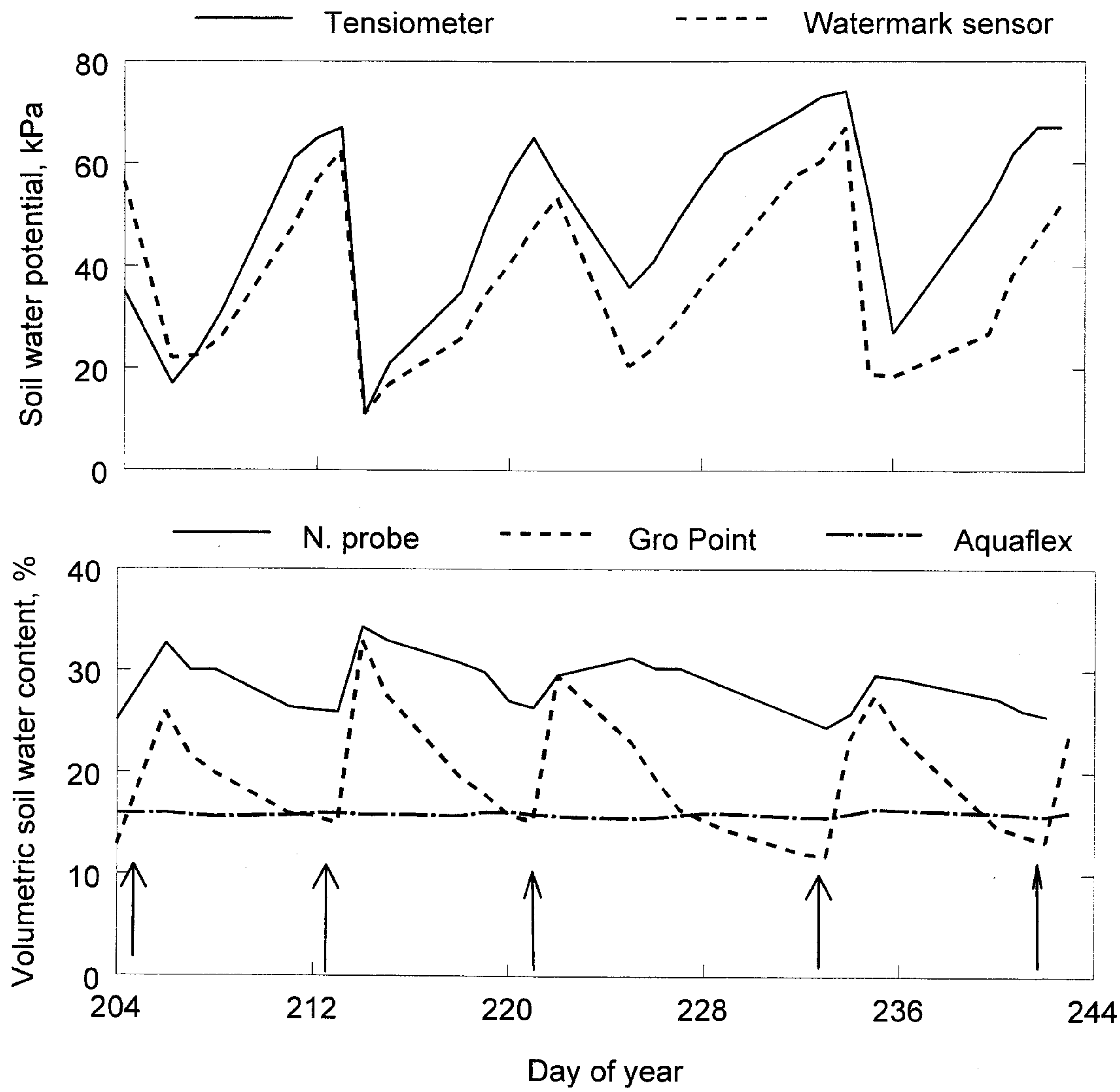

Figure 4. Soil moisture data over time for five types of soil moisture sensors. Arrows denote irrigations with approximately 2 inches of water applied. The Moisture Point sensor was not available during this time due to repairs being made. Malheur Experiment Station, Oregon State University, Ontario, OR.

APPENDIX A. HERBICIDES AND ADJUVANTS

Trade Name	Common or Code Name	Manufacturer
2,4-DB Ester	2,4-DB ester	Aceto Ag Chem
Accent	nicosulfuron	DuPont
Accent Gold	clopyralid+ flumetsulam + nicosulfuron + rimsulfuron	DuPont
Accord	glyphosate	Monsanto
AE F130360 WG70	foramsulfuron	Aventis Crop Sci.
AE F130360 WG62	foramsulfuron	Aventis Crop Sci.
Ally	metsulfuron	DuPont
Assure II	quizalofop	DuPont
AAtrex	atrazine	Syngenta
Atrazine (Several)	atrazine	Various
Banvel	dicamba	BASF
BAS 656 07 H	dimethenamid-p	BASF
BAS 635 00H	experimental	BASF
Basagran	bentazon	BASF
Basis	rimsulfuron + thifensulfuron	DuPont
Basis Gold	nicosulfuron + rimsulfuron + atrazine	DuPont
Betamix	desmedipham + phenmedipham	Aventis Crop Sci.
Betanex	desmedipham	Aventis Crop Sci.
Beyond	imazamox	BASF
Blazer	acifluorfen	BASF
Bronate	bromoxynil + MCPA	Aventis Crop Sci.
Buctril	bromoxynil	Aventis Crop Sci.
Butyrac 200	2,4-DB amine	Albough
Callisto	mesotrione	Syngenta
Clarity	dicamba	BASF
Cobra	lactofen	Valent
Curtail	clopyralid + 2,4-D	Dow Agrosci.
Dacthal	DCPA	Syngenta
Desiccant A	experimental	Summerdale, Inc.
Distinct	diflufenzopyr + dicamba	BASF
Dual, Dual II, Dual Magnum, Dual II Magnum	metolachlor	Syngenta
Eptam	EPTC	Syngenta
Eradicane	EPTC + safener	Syngenta
Escort	metsulfuron	DuPont
Et 751	experimental	Nichino Amer. Inc.
Frontier	dimethenamid	BASF
Goal	oxyfluorfen	Rohm and Haas
Gramoxone Extra	paraquat	Syngenta
Harmony Extra	thifensulfuron + tribenuron	DuPont
Harness	acetochlor + safener	Monsanto

APPENDIX A. HERBICIDES AND ADJUVANTS (*continued*)

Trade Name	Common or Code Name	Manufacturer
Harness Xtra	acetachlor + safener + atrazine	Monsanto
Lasso	alachlor	Monsanto
Liberty	glufosinate	Aventis Crop Sci.
Matrix	rimsulfuron	Dupont
Micro-Tech	alachlor	Monsanto
Oasis	imazapic + 2,4-D ester	BASF
Outlook	dimethenamid-p	BASF
Nortron	ethofumesate	Aventis Crop Sci.
Paramount	quinclorac	BASF
Partner	alachlor	Monsanto
Plateau	imazapic	BASF
Poast, Poast HC	sethoxydim	BASF
Progress	desmedipham + phenmedipham + ethofumesate	Aventis Crop Sci.
Prowl	pendimethalin	BASF
Pursuit	imazethapyr	BASF
Raptor	imazamox	BASF
Reglone	diquat	Syngenta
Rodeo	glyphosate	Monsanto
Ro-Neet	cycloate	Syngenta
Roundup Ultra	glyphosate	Monsanto
Sandea	halosulfuron	Gowan Co.
Select, Prism	clethodim	Valent
Scoil	methylated seed oil	Agsco
Sencor	metribuzin	Bayer
Sinbar	terbacil	DuPont
Sonalan	ethalfluralin	Dow Agrosci.
Spartan	sulfentrazone	FMC
Starane	fluroxypyr	UAP
Steadfast	nicosulfuron + rimsulfuron	DuPont
Stinger	clopyralid	Dow Agrosci.
Sun-It II	methylated seed oil	BASF
Surpass	acetochlor + safener	Syngenta
Topnotch	acetachlor + safener	Syngenta
Tordon	picloram	Dow Agrosci.
Tough	pyridate	Syngenta
Treflan	trifluralin	Dow Agrosci.
Upbeet	triflusulfuron	Dupont
Valor	flumioxazin	Valent
Weedar 64	2,4-D amine	Aventis Crop Sci.
Weedone 638	2,4-D ester + acid	Aventis Crop Sci.
Weedone LV-4	2,4-D ester	Aventis Crop Sci.

APPENDIX B. INSECTICIDES, FUNGICIDES, AND NEMATICIDES

Trade Name	Common or Code Name	Manufacturer
Admire	imidacloprid	Bayer
Agenda	fipronil	Aventis Crop Sci.
Alert	chlorotoluron	Syngenta
Apron Maxx	fenoxam + fludioxonil	Syngenta
Aza-Direct	azadirachtin	Gowan
Bayleton	triadimefon	Bayer
Benlate	benomyl	DuPont
Blocker 4F	pentachloronitrobenzine	Amvac Chem. Corp
Bravo	chlorothalanil	Syngenta
Captan	captan	Micro Flo
Capture	bifenthrin	FMC
Counter 20 CR, Counter 15G	terbufos	BASF
Diazinon AG500	diazinon	Several
Dibrom	naled	UAP
Dithane	mancozeb	Rohm and Haas
Ecozin	azadirachtin	Amvac
EXP 61685A		Aventis Crop Sci.
Fulfill	pymetrozine	Syngenta
Furadan	carbofuran	FMC
Gaucho	imidacloprid	Gowan
Guthion	azinphos-methyl	Bayer
Kocide	copper hydroxide	Griffin
Lannate	methomyl	DuPont
Laredo	myclobutanil	Dow Agrosci.
Lorsban	chlorpyrifos	Dow Agrosci.
Malathion	malathion	UAP
Messenger	harpin protein	Eden Bioscience
Metasystox-R	oxydemeton-methyl	Gowan Company
Mancozeb	mancozeb	
Mustang	zeta-cypermethrin	FMC Corp.
Orthene	acephate	Valent
Raxil XT	tebuconazole + metalaxyl	Gustafson
Ridomil M2	metalaxyl	Syngenta
Ridomyl Gold MZ	metalaxyl	Syngenta
Rotenone	rotenone	
Success	spinosad	Dow Agrosci.
Super-Six	liquid sulfur	Plant Health Tech.
TADS 12253		Aventis Crop Sci.
Telone C-17	dichloropropene + chloropicrin	Dow Agrosci.
Telone II	dichloropropene	Dow Agrosci.
Temik 15G	aldicarb	Aventis Crop Sci.

APPENDIX B. INSECTICIDES, FUNGICIDES, AND NEMATICIDES (*continued*)

Trade Name	Common or Code Name	Manufacturer
Thimet	phorate	BASF
Thiodan	endosulfan	FMC Corp.
Trigard	cyromazine	Syngenta
Warrior	cyhalothrin	Syngenta
Warrior T	cyhalothrin	Syngenta

APPENDIX C. COMMON AND SCIENTIFIC NAMES OF CROPS

Common names	Scientific names
alfalfa	*Medicago sativa*
asparagus	*Asparagus officinalis*
barley	*Hordeum vulgare*
corn	*Zea mays*
dry edible beans	*Phaseolus spp.*
hicksii yew	*Taxus* x *media*
onion	*Allium cepa*
pacific yew	*Taxus brevifolia*
poplar trees, hybrid	*Populus deltoides* x *P. nigra*
potato	*Solanum tuberosum*
soybeans	*Glycine max*
spearmint, peppermint	*Mentha sp.*
squash, honey boat	*Cucurbita maxima*
sugar beet	*Beta vulgaris*
supersweet corn	*Zea mays*
sweet corn	*Zea mays*
triticale	*Triticum* x *Secale*
wheat	*Triticum aestivum*

APPENDIX D. COMMON AND SCIENTIFIC NAMES OF WEEDS

Common names	Scientific names
annual sowthistle	*Sonchus oleraceus*
common groundsel	*Senecio vulgaris*
common lambsquarters	*Chenopodium album*
common mallow	*Malva neglecta*
downy brome	*Bromus tectorum*
green foxtail	*Setaria viridis*
redroot pigweed	*Amaranthus retroflexus*
barnyardgrass	*Echinochloa crus-galli*
kochia	*Kochia scoparia*
hairy nightshade	*Solanum sarrachoides*
hoary cress	*Cardaria draba*
medusahead rye	*Taeniatherum caput-medusae*

APPENDIX D. COMMON AND SCIENTIFIC NAMES OF WEEDS (*continued*)

Common names	Scientific names
perennial ryegrass	*Lolium multiflorum*
puncturevine	*Tribulus terrestris*
quackgrass	*Elytrigia repens*
Russian thistle	*Salsola iberica*
shepherdspurse	*Capsella bursa-pastoris*
wild oat	*Avena fatua*
yellow nutsedge	*Cyperus esculentus*

APPENDIX E. COMMON AND SCIENTIFIC NAMES OF PESTS

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*
sugar beet root maggot	*Tetanops myopaeformis*
willow sharpshooter	*Graphocephala confluens* (Uhler)