STATEMENT FOR TITLE PAGE

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

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

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Oregon Watershed Enhancement Board
U.S. Environmental Protection Agency 319 Program
USDA Cooperative State Research, Education, and Extension Service
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- Summerdale, Inc.
- Syngenta
- T-Systems International
- UAP Northwest
- Valent
- W-L Research

2004 WEATHER REPORT

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Ontario, OR

Introduction

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

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

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

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

Methods

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

Evaporation is measured from April through October as inches of water evaporated from a standard 10-inch-deep by 4-ft-diameter pan over 24 hours. Evapotranspiration (ETc) for each crop is calculated by the AgriMet computer using data from the AgriMet weather station and the Kimberly-Penman equation (Wright 1982). Reference evapotranspiration (ET0) is calculated for a theoretical 12- to 20-inch-tall crop of alfalfa assuming full cover for the whole season. Evapotranspiration for all crops is calculated using ET0 and crop coefficients for each crop. These crop coefficients vary throughout the growing season based on the plant growth stage. The crop coefficients are tied to the plant growth stage by three dates: start, full cover, and termination dates. Start dates are the beginning of vegetative growth in the spring for perennial crops or the emergence date for row crops. Full cover dates are typically when plants reach full foliage. Termination dates are defined by harvest, frost, or dormancy. Alfalfa mean ETc is calculated for an alfalfa crop assuming a 15 percent reduction to account for cuttings.

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

2004 Weather

The total precipitation for 2004 (11.98 inches) was higher than the 10-year (10.19 inches) and 60-year (10.16 inches) averages (Table 1). Precipitation in October was about three times the 10-year and 60-year averages. Total snowfall for 2004 (24 inches) was higher than the 10-year (14.0 inches) and 61-year averages (18.2 inches) (Table 2).

The highest temperature for 2004 was 104°F on July 18 (Table 3). The lowest temperature for the year was -1°F on January 5. The average maximum and minimum air temperatures for March were substantially higher than the 10-year and 60-year averages. March 31 reached 80°F.

March had the highest number of growing degree days (50° to 86°F) for that month since 1986, when measurements were started (Table 4, Fig. 1). The total number of degree days in the above-optimal range in 2004 was close to the average (Table 5).

The months of May through December had total wind runs lower than the 10-year average (Table 6). Total pan-evaporation for 2004 was close to the 10-year and 56-year averages (Table 7). Total accumulated ETc for all crops in 2004 was close to the 10-year average (Table 8).

The average monthly maximum and minimum 4-inch soil temperatures in 2004 were close to the 10-year and 37-year averages (Table 9).

The last spring frost ([32°F) occurred on April 16, 13 days earlier than the 28-year average date of April 29; the first fall frost occurred on October 24, 19 days later than the 28-year average date of October 5 (Table 10). The 191 frost-free days was the longest frost-free period over the last 14 years.

No other weather records were broken in 2004 (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, 1991-2004.

Table 2. Annual snowfall totals at the Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2004.

Table 3. Monthly air temperature, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Figure 1. Cumulative growing degree days (50-86°F) over time for selected years compared to 14-year average, Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 4. Monthly total growing degree days (50-86°F), Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2004.

Table 5. Monthly total degree days in the above-ideal (86 -104°F) range, Malheur Experiment Station, Oregon State University, Ontario, OR, 1991-2004.

Table 6. Wind-run daily totals and monthly totals, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 7. Pan-evaporation totals, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 8. Total accumulated reference evapotranspiration (ET0) and crop evapotranspiration (ETc) (acre-inches/acre), Malheur Experiment Station, Oregon State University, Ontario, OR, 1992-2004.

Table 9. Monthly soil temperature at 4-inch depth, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 10. Last and first frost ([32°F) dates and number of frost-free days, Malheur Experiment Station, Oregon State University, Ontario, OR, 1990-2004.

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

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APPENDICES

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

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Introduction

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

Methods

The trial was established on Owyhee silt loam where winter wheat was the previous crop and alfalfa had not been grown for more than 10 years. Pathfinder (Nelson Irrigation Corp., Walla Walla, WA) drip tape (15 mil thick, 0.22 gal/min/100-ft flow rate, 12-inch emitter spacing) was shanked in at a depth of 12 inches on 30-inch spacing between the drip tapes. Plots were 5 ft wide by 20 ft long in a randomized complete block design with each entry replicated five times. Further details of the establishment of this trial were reported previously (Eldredge et al. 2003).

Gramoxone® at 2 pint/acre plus Sencor® at 1.5 pint/acre were applied for weed control on March 11, 2004. No irrigations were applied before the first cutting in 2004. After the first cutting, irrigations were semi-automated using a valve controller (DIG Corp. Vista, CA) initially programmed to apply a 1-inch irrigation twice weekly, on Mondays and Thursdays. Alfalfa crop evapotranspiration (ET_c) was calculated based on data collected by an AgriMet (U.S. Bureau of Reclamation, Boise, ID) weather station located on the Malheur Experiment Station. Soil moisture was monitored by six Watermark soil moisture sensors model 200SS (Irrometer Co. Inc., Riverside, CA) installed at 12-inch depth in the center of six alfalfa plots, midway between drip tapes. Sensors were connected to an AM400 data logger (M.K. Hansen, East Wenatchee, WA) equipped with a thermistor to correct soil moisture calculations for soil temperature. Water applied was measured by a totalizing water meter on the inlet of the irrigation system. A rodenticide, Maki bromadiolone supercade bait (Liphatech, Inc., Milwaukee, WI), was applied in rodent tunnels on July 22 with a gopher probe (Eagle Industries, Chatsworth, CA).

The alfalfa was harvested at bud stage on May 14, June 17, July 19, August 13, and September 22, 2004. A 3-ft by 20-ft swath was cut from the center of each plot with a flail mower, and the alfalfa was weighed. Ten samples of alfalfa were hand cut from border areas of plots over the entire field on the same day just before each cutting, quickly weighed, dried in a forage drier at 140°F with forced air, and reweighed to determine the average alfalfa moisture content at each cutting. Yield was reported as tons per acre of alfalfa hay at 88 percent dry matter.

Samples of alfalfa from approximately 1 ft of row per plot were taken June 16, before the second cutting, to measure forage quality. The forage quality samples were dried, ground in a Wiley mill (Thomas Scientific, Swedesboro, NJ) to pass through a 1-mm screen, subsampled, and sent to the Oregon State University Forage Quality Lab at Klamath Falls, Oregon, where they were reground in a UDY mill (UDY Corp., Ft. Collins, CO) to pass through a 0.5-mm screen. Near infrared spectroscopy (NIRS) was used to estimate percent dry matter, percent crude protein, percent acid detergent fiber (ADF), percent neutral detergent fiber (NDF), percent fat, and percent ash. Relative forage quality (RFQ) was calculated by the formula:

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

where:
DMI = dry matter intake (for alfalfa hay), and
DMI = (((0.120 * 1350) / (NDF/100)) + (NDFD - 45) * 0.374) / 1350 * 100, and
NDFD = dNDF48 / NDF * 100, and
dNDF48 = digestible NDF as a percentage of dry matter, as determined by a 48-hour in vitro digestion test,
TDNL = total digestible nutrients [for legume (alfalfa hay)]
TDNL = (NFC * 0.98) + (protein * 0.93) + (fat * 0.97 * 2.25) + ((NDF-2) * (NDFD/100))
NFC = 100 - ((NDF - 2) + protein + 2.5 + ash), and 1.23 was chosen as the denominator to adjust the scale to match the RFV scale at 100 = full bloom alfalfa.

Quality standards based on RFQ are: Supreme, RFQ higher than 185; Premium, RFQ 170-184; Good, RFQ 150-169; Fair, RFQ 130-149, and Low, RFQ below 129. RFQ estimates voluntary energy intake when the hay is the only source of energy and protein for ruminants. Hay with a higher RFQ requires less grain or feed concentrate to formulate dairy rations.

Results and Discussion

Rodents chewed holes in the drip tape and continued to be a problem in this trial. During the winter, voles burrowed down to the drip tape and chewed holes that were found and repaired at the first irrigation. The rodenticide applied in the vole tunnels was effective until the grain crop adjacent to the alfalfa trial was harvested. After the grain harvest, a new population of voles gradually colonized the alfalfa trial. A gopher that moved into the trial was promptly exterminated.

Soil moisture was monitored at the 12-inch depth after first cutting (Fig. 1). After June 8, the soil remained uniformly moist in the –20 to –30 kPa (centibar) range for the rest of the irrigation season.

The total irrigation water applied was less than the season-long accumulated alfalfa crop evapotranspiration (Fig. 2). The irrigation system was turned off for harvest operations and to repair leaks. Smaller irrigations, from 0.01 to 0.38 inch, were applied on seven dates through the summer in order to check for leaks or following repairs to the drip tape. Accumulated season-long alfalfa ET_c from March 5 to October 10 totaled 43.38 inches, and the drip irrigation measured by the water meter, plus rain, totaled 31.81 inches or 73.3 percent of accumulated season-long alfalfa ET_c.

The average third-year total hay yield was 7.9 ton/acre (Table 1). The first-cutting average yield was 2.5 ton/acre, with 'SX1002A' 'Masterpiece', and 'SX1001A' yielding among the highest. In the second cutting 'Ruccus', Masterpiece, 'Tango', 'Orestan', and 'Somerset' were among the highest yielding varieties. In the third cutting, Ruccus, 'Lahontan', Masterpiece, Orestan, and Tango were among the highest yielding varieties. In the fourth cutting, Ruccus, Tango, Orestan, and Lahontan were among the highest yielding. In the fifth cutting, Ruccus, 'Plumas', and Somerset were among the highest yielding varieties. In total yield of five cuttings, Ruccus, with 8.4 ton/acre, Masterpiece, with 8.2 ton/acre, and Tango, SX1002A, and Orestan each with 8.0 ton/acre, were among the highest yielding.

The crude protein averaged 25.6 percent in the second cutting, and ranged from 24.3 percent for Orestan to 26.7 percent for Somerset. Acid detergent fiber, ADF, averaged 26.7 percent. Neutral detergent fiber, NDF, averaged 31.2 percent. Relative forage quality averaged 245, with all varieties in the "Supreme" quality range. SX1005A, Plumas, Somerset, and Masterpiece produced hay with RFQ scores higher than 247.

Total hay production in the first 3 years averaged 18.3 ton/acre (Table 2). The varieties Ruccus, at 20.1 ton/acre; Tango, at 19.4 ton/acre; and Masterpiece, at 19.3 ton/acre were among the highest yielding.

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

References

Eldredge, E.P, C.C. Shock, and L. D. Saunders. 2003. First year results of the 2002 to 2006 alfalfa forage variety trial. Oregon State University Special Report 1048:14-17. Available online at www.cropinfo.net/AnnualReports/2002/B5aDripAlf02.htm

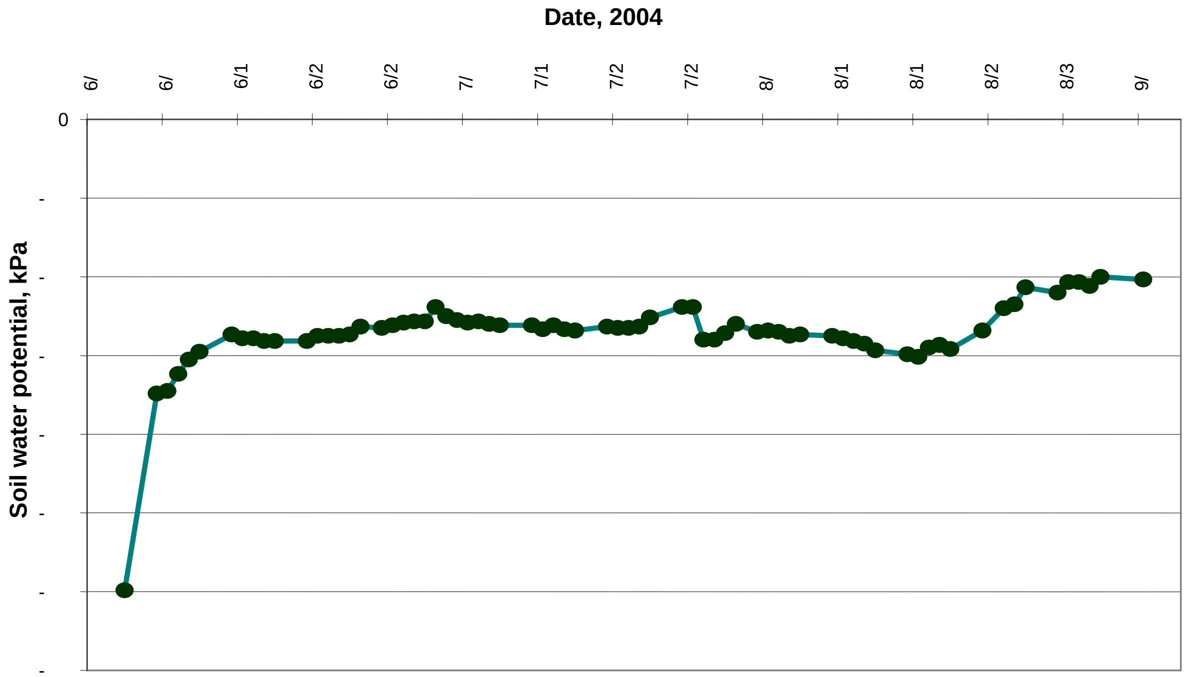

Figure 1. Soil moisture in the drip-irrigated alfalfa variety trial during the 2004 growing season, Malheur Experiment Station, Oregon State University, Ontario, OR.

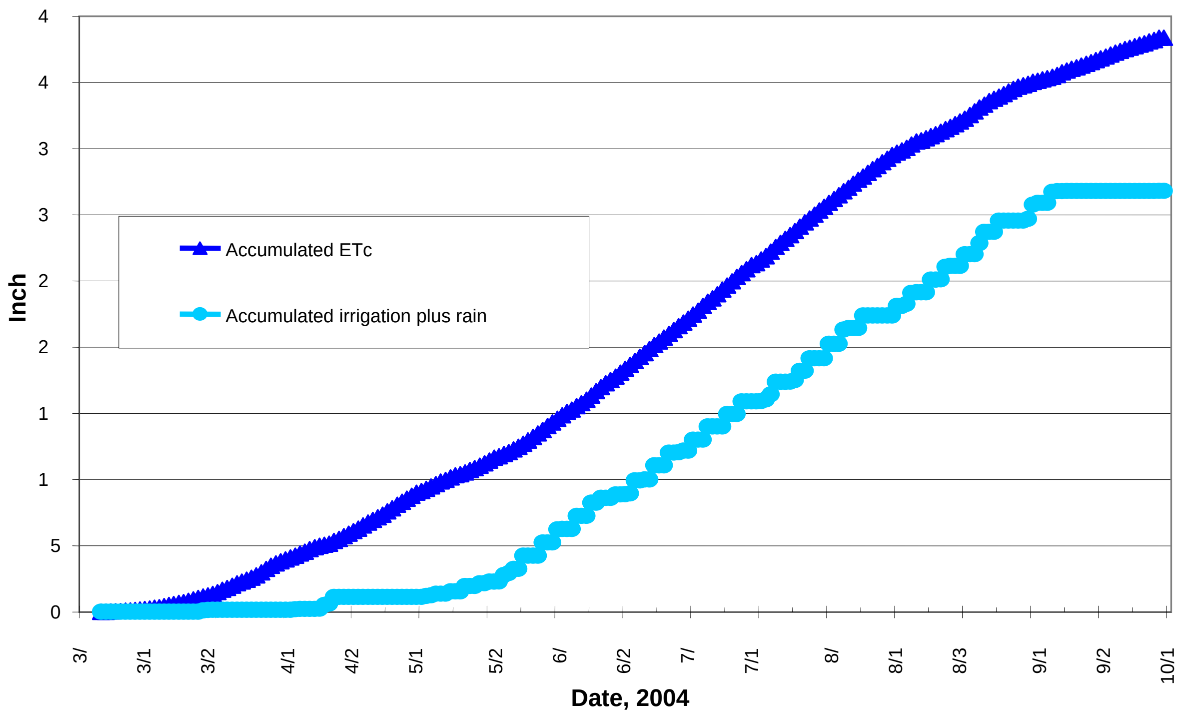

Figure 2. Accumulated irrigation applied plus rain compared to the AgriMet accumulated evapotranspiration (ET_c) for alfalfa grown for hay, Malheur Experiment Station, Oregon State University, Ontario, OR 2004.

Table 1. Alfalfa variety hay yields and second-cutting crude protein*, ADF*, NDF*, and relative forage quality for 2004, Malheur Experiment Station, Oregon State University, Ontario, OR.

Variety	Cutting date 5/14	6/17	7/19	8/13	9/22	2004 total	Crude protein	ADF†	NDF‡	Relative forage quality
	ton/acre§						% of DW¶			RFQ
Ruccus	2.4	1.4	2.0	1.2	1.3	8.4	26.0	27.0	31.5	239
Masterpiece	2.7	1.3	1.9	1.1	1.2	8.2	25.1	26.1	30.7	251
Tango	2.5	1.3	1.9	1.2	1.2	8.0	25.2	28.0	32.9	228
SX1002A	2.9	1.2	1.7	1.1	1.2	8.0	25.1	27.4	32.3	233
Orestan	2.4	1.3	1.9	1.2	1.2	8.0	24.3	29.0	34.2	213
Lahontan	2.3	1.2	2.0	1.2	1.2	7.9	25.8	26.7	31.3	243
Plumas	2.6	1.2	1.8	1.0	1.3	7.9	26.6	24.9	29.2	267
SX1001A	2.7	1.2	1.7	1.0	1.2	7.9	25.4	26.3	31.2	244
Somerset	2.4	1.3	1.8	1.1	1.3	7.9	26.7	26.1	30.3	253
SX1003A	2.5	1.2	1.6	1.0	1.2	7.5	25.5	26.5	31.0	246
SX1005A	2.5	1.1	1.7	1.0	1.1	7.4	26.4	25.1	29.1	271
SX1004A	2.3	1.2	1.5	1.0	1.2	7.4	25.5	26.8	31.2	247
Mean	2.5	1.2	1.8	1.1	1.2	7.9	25.6	26.7	31.2	245
LSD (0.05)	0.29	0.09	0.18	0.07	0.10	0.47	1.27	1.74	2.26	23.7

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

Table 2. Alfalfa variety hay yields in the first 3 years of the 2002-2006 drip-irrigated alfalfa variety trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Variety	Yield 2002*	2003	2004	Cumulative
	ton/acre†			
Ruccus	2.6	9.1	8.4	20.1
Tango	2.5	9.0	8.0	19.4
Masterpiece	2.4	8.7	8.2	19.3
Somerset	2.4	8.5	7.9	18.8
Orestan	2.2	8.4	8.0	18.7
Plumas	2.6	8.1	7.9	18.5
Lahontan	2.0	8.1	7.9	18.1
SX1001A	2.1	8.0	7.9	18.0
SX1002A	1.9	7.7	8.0	17.7
SX1005A	2.4	7.7	7.4	17.5
SX1004A	2.1	7.5	7.4	16.9
SX1003A	2.0	7.0	7.5	16.5
Mean	2.3	8.2	7.9	18.3
LSD (0.05)	0.40	0.54	0.47	0.94

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

Table 3. Variety source, year of release, fall dormancy, and level of resistance to pests and diseases for 12 alfalfa varieties in the 2002-2006 drip-irrigated forage variety trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

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

*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).

†Pest resistance rating: >50 percent = HR (high resistance), 31-50 percent = R (resistant), 15-30 percent = MR (moderate resistance), 6-14 percent = LR (low resistance).

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

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

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

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Introduction

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

Materials and Methods

The soil was formed into 22-inch beds on May 10. Plots were sidedressed with 126 lb nitrogen (N), 14 lb sulfates, 3 lb zinc, 1 lb boron, 1 lb manganese, and 38 lb elemental sulfur/acre on May 11. Pioneer variety 'P-36N69' Roundup Ready® field corn was planted with a John Deere model 71 Flexi Planter on May 17. Seed spacing was one seed every 7 inches. Plots were 7.33 by 30 ft and herbicide treatments were arranged in a randomized complete block with four replicates. Herbicide treatments were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Crop response and weed control were evaluated throughout the growing season. Corn yields were determined by harvesting ears from 26-ft sections of the center 2 rows in each 4-row plot on October 11. The harvested ears were shelled and grain weight and percent moisture content were recorded. Grain yields were adjusted to 12 percent moisture content. Data were analyzed using analysis of variance (ANOVA) and treatment means were separated using Fisher's protected least significant difference (LSD) at the 5 percent level (P = 0.05).

Postemergence treatments of Option, Clarion®, or Roundup® were applied alone and in combinations with other herbicides and with or without preemergence (PRE) Dual Magnum®. PRE applications were made May 21. Mid-postemergence (MP) treatments were applied to corn at the V4 growth stage on June 11, and late postemergence treatments (LP) were applied to corn at the V6 growth stage on June 19. Option was applied with various additives as well as in combination with Distinct® or Callisto®. Option combinations were compared to Clarion applied alone and in combination with Distinct or to Roundup applied alone or following PRE Dual Magnum. The herbicide rates and combinations are shown in Table 1.

Results and Discussion

Control of pigweed species (i.e., Powell amaranth and redroot pigweed) ranged from 91 to 100 percent on July 23 and was similar among herbicide treatments. One exception was the treatment with Option, Dyne-Amic®, and 32 percent N, which provided only 91 percent control (Table 1). When Option was applied with Dyne-Amic and 32 percent N or Quest®, common lambsquarters control also was lower than all other treatments. Clarion alone also provided less common lambsquarters control than all other treatments except for Option applied with Dyne-Amic. Combinations of Option with Distinct or Callisto, and the combination of Clarion and Distinct provided among the best common lamsquarters control. Common lambsquarters control was improved when Roundup was applied following PRE Dual Magnum compared to Roundup applied alone. Clarion alone provided the least hairy nightshade control, and the combination of Clarion and Distinct also provided less hairy nightshade control compared to all other treatments except Option with Dyne-Amic and 32 percent N. There were no significant differences in kochia and barnyardgrass control among treatments.

Injury from herbicide treatments ranged from 0 to 14 percent on June 19 and was 4 percent or less on July 2 (Table 2). Corn yields ranged from a low of 103 bu/acre with the untreated control to a high of 194 bu/acre with the combination of Option and Callisto (Table 2). The treatment containing Option with Dyne-Amic and 32 percent N had lower yields than many of the other Option treatments and was likely due to reduced weed control with that treatment.

The selection of additives can significantly affect the efficacy of Option against pigweed species, common lambsquarters, and hairy nightshade. The addition of Distinct or Callisto to Option can significantly improve common lambsquarters control.

Table 1. Weed control with Option® herbicide applied in field corn, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Rate*	Timing[†]	Weed control[§] Pigweed spp[‡]	C. lambs-quarters	H. night-shade	Kochia	Barnyard-grass
	lb ai/acre pt/acre % v/v		----- % -----				
Option + MSO + 32% N	0.033 + 1.5 + 3.0	MP	100	79	92	96	97
Option + MSO + AMS	0.033 + 1.5 + 3.0	MP	100	88	99	97	100
Option + DYNE-AMIC + 32% N	0.033 + 0.25% + 3.0	MP	91	45	76	95	94
Option + MSO + QUEST	0.033 + 1.5 +2.5%	MP	98	89	98	100	97
Clarion + MSO + 32% N	0.023 + 1.5 +4	MP	98	61	52	98	99
Option + MSO + 32% N	0.033 + 1.5 +3.0	MP	99	89	94	100	97
Option + Distinct + MSO + 32% N	0.033 + 0.088 + 1.5 + 3.0	MP	100	100	96	100	96
Option + Distinct + MSO + 32% N	0.33 + 0.175 + 1.5 + 3.0	MP	100	100	99	100	97
Clarion + Distinct + NIS + 32% N	0.023 + 0.088 + 0.5% + 4.0	MP	100	97	73	100	100
Option + Callisto + MSO + 32% N	0.033 + 0.0625 + 1.5 + 3.0	MP	99	100	97	100	98
Dual II Magnum Option + MSO + 32% N	1.6 0.033 + 1.5 + 3.0	PRE LP	97	90	85	100	100
Option + MSO + AMS	0.033 + 1.5 +3	MP	99	88	97	99	96
Option + DYNE-AMIC + Quest	0.033 + 0.25 % + 0.25%	MP	97	48	88	99	100
Roundup Ultramax	0.58	MP	99	81	95	100	97
Dual II Magnum Roundup Ultramax + AMS	1.6 0.58 + 3.0	PRE LP	100	92	90	100	99
LSD (0.05)			3	6	11	NS	NS

*Herbicide rates are in lb ai/acre. Additive rates are in pt/acre or percent v/v.
[†]Application timings were preemergence (PRE) on May 21, mid-postemergence (MP) applied to corn at the V4 growth stage on June 11, and late postemergence (LP) to corn at the V6 growth stage on June 19.
[‡]Pigweed species were a mixture of Powell amaranth and redroot pigweed.
[§]Weed control was evaluated July 23. The untreated control was not included in the ANOVA for weed control.

Table 2. Injury and yield with Option® herbicide applied in field corn, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

			Field corn		
			Injury‡		
Treatment	Rate*	Timing†	6-19	7-2	Yield§
	lb ai/acre pt/acre % v/v		%		bu/acre
Untreated control	--	--	--	--	103
Option + MSO + 32% N	0.033 + 1.5 + 3.0	MP	8	0	179
Option + MSO + AMS	0.033 + 1.5 + 3.0	MP	9	0	187
Option + DYNE-AMIC + 32% N	0.033 + 0.25% + 3.0	MP	5	0	157
Option + MSO + QUEST	0.033 + 1.5 +2.5%	MP	10	0	192
Clarion + MSO + 32% N	0.023 + 1.5 +4	MP	3	0	178
Option + MSO + 32% N	0.033 + 1.5 +3.0	MP	9	3	174
Option + Distinct + MSO + 32% N	0.033 + 0.088 + 1.5 + 3.0	MP	11	0	183
Option + Distinct + MSO + 32% N	0.33 + 0.175 + 1.5 + 3.0	MP	14	4	178
Clarion + Distinct + NIS + 32% N	0.023 + 0.088 + 0.5% + 4.0	MP	6	1	189
Option + Callisto + MSO + 32% N	0.033 + 0.0625 + 1.5 + 3.0	MP	5	0	194
Dual II Magnum Option + MSO + 32% N	1.6 0.033 + 1.5 + 3.0	PRE LP	9	3	184
Option + MSO + AMS dry	0.033 + 1.5 +3	MP	9	0	178
Option + DYNE-AMIC + Quest	0.033 + 0.25 % + 0.25%	MP	1	0	178
Roundup Ultramax	0.58	MP	0	0	189
Dual II Magnum Roundup Ultramax + AMS	1.6 0.58 + 3.0	PRE LP	0	0	173
LSD (0.05)	--	--	4.5	2	21

*Herbicide rates are in lb ai/acre. Additive rates are in pt/acre or percent v/v.
†Application timings were preemergence (PRE) on May 21, mid-postemergence (MP) applied to corn at the V4 growth stage on June 11, and late postemergence (LP) to corn at the V6 growth stage on June 19.
‡The untreated control was not included in the ANOVA for percent injury.
§Corn was harvested October 11 and yields were adjusted to 12 percent moisture content.

EVALUATIONS OF SPRING HERBICIDE APPLICATIONS TO DORMANT MINT

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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. Herbicides are important tools for controlling weeds in mint. With the constant loss of herbicides that are registered for use in mint, it is critical to identify replacements that will provide similar weed control. Several new herbicides that have recently become available or may be available in the near future have been tested in mint. This research evaluated herbicides that have been used traditionally with new herbicide combinations containing some recently registered herbicides including Spartan® (sulfentrazone), Chateau® (flumioxazin), and Command® (clomazone).

Materials and Methods

Two trials were established to evaluate spring herbicide applications to dormant mint for mint tolerance and weed control efficacy. One trial was established near Nampa, Idaho and the other near Nyssa, Oregon. Perennial weed problems and a poor mint stand resulted in abandonment of the Oregon location. Herbicides that were evaluated included a standard of Sinbar®, Karmex®, Stinger®, and Prowl® compared to various combinations that included Spartan, Chateau, and Command. Treatments were applied March 3, 2004 when mint was still mostly dormant. Herbicide treatments were arranged in a randomized block design with four replicates. Plots were 10 ft wide by 30 ft long. Herbicides were applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Visual evaluations of mint injury and weed control were made throughout the season. Mint yield was determined by harvesting mint from 3 yd^2 from the center of each plot. After the mint fresh weight was recorded, a 20-lb sub-sample was taken and allowed to dry in burlap bags. Once samples were dry, mint oil was extracted at the University of Idaho mint research still. Distillation was done according to the Mint Industry Research Council (MIRC) protocol.

Results and Discussion

Only the treatment containing Command, Spartan, and Stinger caused significant mint injury on April 27 (Table 1). The same combination with Spartan at a lower rate caused significantly less mint injury, as did the combination of Command, Spartan, and Gramoxone®. By June 7, no significant injury was visible for any treatment. Prickly lettuce populations were variable, and variability among prickly lettuce control evaluations resulted in no statistical differences among herbicide treatments. Kochia densities were too low for visual control evaluation, but counts of all the kochia in each plot revealed that all but two treatments significantly reduced kochia numbers compared to the untreated check. The combination of Sinbar, Karmex, Stinger, and Chateau and the combination of Command, Chateau, and Gramoxone did not significantly reduce kochia numbers. Mint fresh weight and oil yields were strongly correlated with prickly lettuce control and kochia densities (Fig. 1). All treatments increased mint yield compared to the untreated control. The combination of Command, Chateau, and Gramoxone produced lower mint fresh weight and oil yields than all other treatments except combinations of Command, Spartan, and Gramoxone, but had similar oil yields compared to the combination of Sinbar, Karmex, Singer, and Prowl.

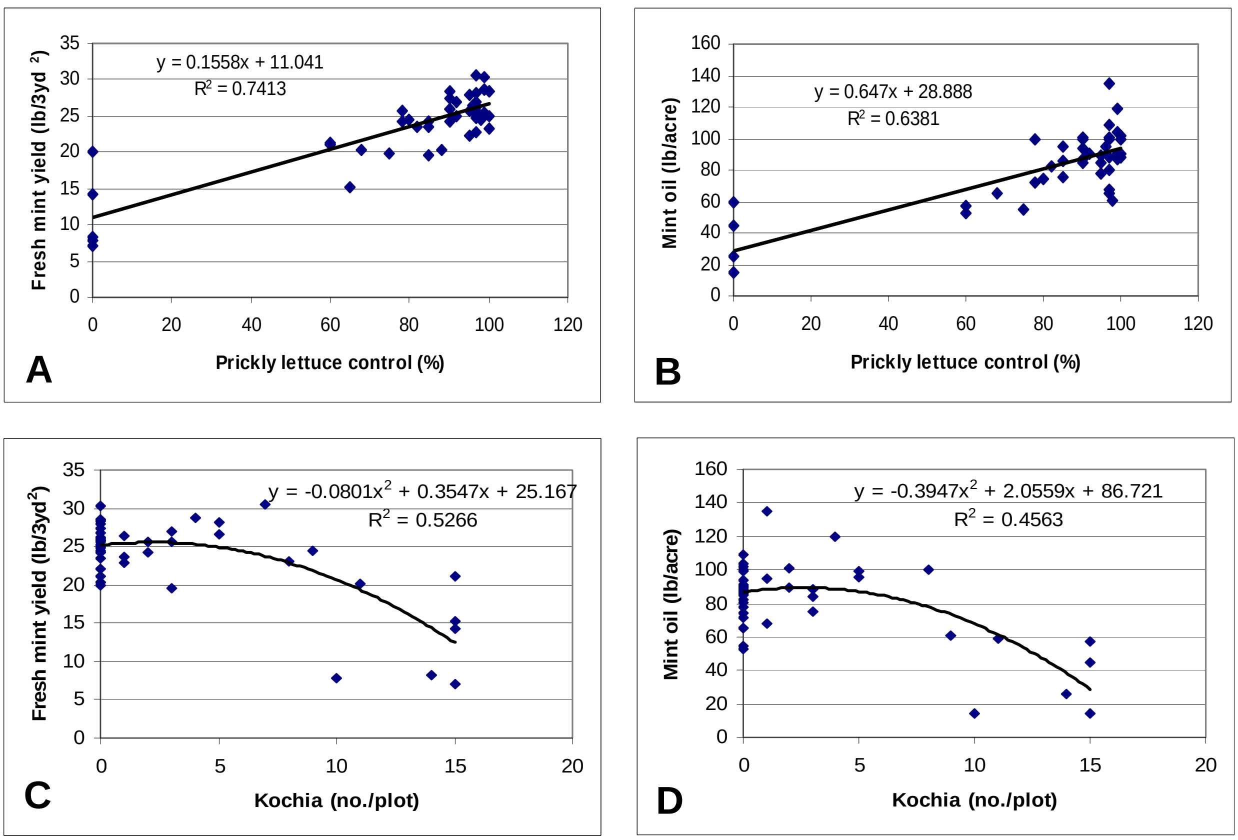

Figure 1. Mint fresh hay and oil yield as influenced by prickly lettuce control (A and B) and kochia density (C and D) in Nampa, ID, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004. For all regressions $P < 0.0000$.

Table 1. Mint injury and weed control from spring herbicide applications to dormant peppermint in Nampa, ID, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

		Mint injury		Weed control: Prickly lettuce			Kochia density[‡]	Mint yield: Fresh Wt.	Mint yield: Oil
Treatment*	Rate[†]	4-27	6-7	4-27	6-7	7-28	7-28	8-25	8-25
	lb ai/acre	%	%	%	%	%	no/plot	lb/3 yd^2	lb/acre
Untreated control	--	-	-	-	-	-	13 a	8.7	28
Sinbar + Karmex + Stinger + Prowl + NIS	0.6 + 0.8 + 0.124 + 1.5 + 0.25%	3	5	84	86	87	2 b	19.5	82
Sinbar + Karmex + Stinger + Spartan + NIS	0.6 + 0.8 + 0.124 + 0.188 + 0.25%	0	3	96	94	96	0 b	21.0	95
Sinbar + Karmex + Stinger + Chateau + NIS	0.6 + 0.8 + 0.124 + 0.125 + 0.25%	5	4	94	94	98	5 ab	20.8	96
Command + Spartan + Stinger + NIS	0.375 + 0.188 + 0.124 + 0.25%	21	5	81	84	90	0 b	21.0	103
Command + Chateau + Stinger + NIS	0.375 + 0.125 + 0.124 + 0.25%	5	4	95	92	95	4 b	21.6	84
Command + Spartan + Gramoxone Extra + NIS	0.375 + 0.188 + 0.375 + 0.25%	8	4	70	66	83	4 b	18.9	77
Command + Chateau + Gramoxone Extra + NIS	0.375 + 0.125 + 0.375 + 0.25%	4	4	59	58	59	8 ab	15.1	58
Sinbar + Karmex + Stinger + Spartan + NIS	0.6 + 0.8 + 0.124 + 0.125 + 0.25%	6	4	92	90	89	2 b	19.4	92
Command + Spartan + Stinger + NIS	0.375 + 0.125 + 0.124 + 0.25%	9	5	91	89	94	1 b	22.2	97
Command + Spartan + Gramoxone Extra + NIS	0.375 + 0.125 + 0.375 + 0.25%	4	5	76	60	78	0 b	19.0	74
Command + Spartan + Stinger + Buctril + NIS	0.375 + 0.125 + 0.124 + 0.25 + 0.25%	3	5	83	86	93	1 b	20.6	96
LSD (0.05)		10	NS	NS	NS	NS	-	4.1	24

*Treatments were applied March 3, 2004 to dormant mint.

[†]Herbicide rates are lb ai/acre. NIS (nonionic surfactant, Activator 90) was applied at 0.25 percent v/v.

[‡]Mean separation is based on transformed data. Raw data are presented.

2004 ONION VARIETY TRIALS

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Introduction

The objective of the onion variety trials was to evaluate yellow, white, and red onion varieties for bulb yield, quality, and single centers. Five early season yellow varieties and one early season white variety were planted in March and were harvested and graded in August. Forty-three full season varieties (33 yellow, 5 red, and 5 white) were planted in March, harvested in September 2004, and evaluated in January 2005.

Methods

The onions were grown on an Owyhee silt loam previously planted to wheat. Soil analysis indicated the need for 60 lb nitrogen (N)/acre, 100 lb phosphate (P_2O_5)/acre, 70 lb sulfur/acre, 2 lb copper/acre, 7 lb zinc/acre, and 1 lb boron/acre, which was broadcast in the fall. In the fall of 2003, the wheat stubble was shredded, and the field was disked, irrigated, ripped, moldboard-plowed, roller-harrowed, fumigated with
Telone C-17® at 20 gal/acre, and bedded. A soil sample taken on May 20, 2004 showed a pH of 7.3, 2 percent organic matter, 8 ppm nitrate-N, 37 ppm phosphorus, and 461 ppm potassium.

A full season trial and an early maturing trial were conducted adjacent to each other. Both trials were planted on March 19 in plots four double rows wide and 27 ft long. The early maturing trial had 6 varieties from 3 companies (Table 1) and the full season trial had 43 varieties from 10 companies (Table 2). The experimental design for both trials was a randomized complete block with five replicates. A sixth nonrandomized replicate was planted for demonstrating onion variety performance to growers and seed company representatives.

Seed was planted in double rows spaced 3 inches apart at 9 seeds/ft of single row. Each double row was planted on beds spaced 22 inches apart with a customized planter using John Deere Flexi Planter units equipped with disc openers. The onion rows received 3.7 oz of Lorsban 15G® per 1,000 ft of row (0.82 lb ai/acre), and the soil surface was rolled on March 20. The field was irrigated on March 25. On March 31 the field was sprayed with Roundup® at 24 oz/acre. Onion emergence started on April 5. On May 4, alleys 4 ft wide were cut between plots, leaving plots 23 ft long. From May 5 through 8, the seedlings were hand thinned to a plant population of two plants/ft of single row (6-inch spacing between individual onion plants, or 95,000 plants/acre). The field was sidedressed with 100 lb of N/acre as urea and cultivated on May 12. On June 9 the field was sidedressed with 100 lb N/acre as urea.

The onions were managed to avoid yield reductions from weeds, pests, and diseases. Weeds were controlled with an application of Prowl® at 0.75 lb ai/acre on April 12 and on May 12, and an application of Goal® at 0.12 lb ai/acre, Buctril® at 0.12 lb ai/acre, and Poast® at 0.28 lb ai/acre on May 25. After lay-by the field was hand weeded as necessary. Thrips were controlled with aerial applications of Warrior® on June 12, Warrior (0.03 lb ai/acre) plus Lannate® (0.4 lb ai/acre) on June 25, Warrior (0.03 lb ai/acre) plus MSR® (0.5 lb ai/acre) on July 17, and Warrior (0.03 lb ai/acre) plus Lannate (0.4 lb ai/acre) on July 31.

The trial was furrow irrigated when the soil water potential at 8-inch depth reached -25 kPa. Soil water potential was monitored by thirteen granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co. Inc., Riverside, CA) installed in mid-June below the onion row at 8-inch depth. Six sensors were automatically read three times a day with an AM-400 meter (Mike Hansen Co., East Wenatchee, WA). Seven sensors were automatically read hourly with a Watermark Monitor (Irrometer Co., Inc.). The last irrigation was on August 20.

Onions in each plot were evaluated subjectively for maturity by visually rating the percentage of onions with the tops down and the percent dryness of the foliage. The percent maturity was calculated as the average percentage of onions with tops down and the percent dryness. The early maturing trial was evaluated for maturity on August 10 and the full season trial on August 24. The number of bolted onion plants in each plot was counted.

Onions in each plot were evaluated subjectively for damage from iris yellow spot virus on August 11. Each plot was rated according to the number of leaves with symptoms per plant: 0 = no symptoms, 5 = at least 3 leaves with symptoms per plant.

Onions from the middle two rows in each plot in the early maturity trial were lifted on August 13, and topped by hand and bagged on August 17. On August 20 the onions were graded. The onions in the full season trial were lifted on September 8 to field cure. Onions from the middle two rows in each plot of the full season trial were topped by hand and bagged on September 15. The bags were put in storage on September 22. The storage shed was managed to maintain an air temperature as close to 34°F as possible. Onions from the full season trial were graded out of storage on January 11 and 12, 2005.

During grading, bulbs were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), neck rot (bulbs infected with the fungus Botrytis allii in the neck or side), plate rot (bulbs infected with the fungus Fusarium oxysporum), and black mold (bulbs infected with the fungus Aspergillus niger). The No. 1 bulbs were graded according to diameter: small (<2.25 inches), medium (2.25-3 inches), jumbo (3-4 inches), colossal (4-4.25 inches), and supercolossal (>4.25 inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading. The red varieties were evaluated subjectively during grading for exterior thrips damage during storage. The bulbs from each red variety plot were rated on a scale from 0 (no damage) to 10 (most damage) for the damage that was apparent on the bulb surface, without removing the outer scales.

In early September bulbs from one of the border rows in each plot of both trials were rated for single centers. Twenty-five consecutive onions ranging in diameter from 3.5 to 4.25 inches were rated. The onions were cut equatorially through the bulb middle and, if multiple centered, the long axis of the inside diameter of the first single ring was measured. These multiple-centered onions were ranked according to the diameter of the first single ring: "small double" had diameters less than 1.5 inches, “intermediate double” had diameters from 1.5 to 2.25 inches, and “blowout” had diameters greater than 2.25 inches. Single-centered onions were classed as a “bullet”. Onions were considered functionally single centered for processing if they were a “bullet” or “small double.”

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

Results

Varieties are listed by company in alphabetical order. The LSD (0.05) values at the bottom of each table should be considered when comparisons are made between varieties for significant differences in performance characteristics. Differences between varieties equal to or greater than the LSD value for a characteristic should exist before any variety is considered different from any other variety in that characteristic.

A few experimental varieties were named in 2004. Nunhems’ ‘SX 7000ON’ and ‘SX 7002ON’ were named ‘Bandolero’ and ‘Montero’, respectively. Seedworks’ ‘6001’ was named ‘Maverick’. Varieties are all listed by name in the results. The experimental numbers are useful for comparing results from previous years.

Iris Yellow Spot Virus Rating

Subjective rating of damage from iris yellow spot virus for the early maturing varieties ranged from 0.68 for ‘Renegade’ to 1.84 for ‘XON-0101’ (Table 1). Subjective rating of damage from iris yellow spot virus for the full season varieties ranged from 0.82 for ‘T-433’, ‘Delgado’, and ‘PX 5299’ to 1.92 for ‘Export 151’ (Table 3).

Early Maturity Trial, Five Yellow Varieties, One White Variety

The percentage of “bullet” single centers averaged 20.6 percent and ranged from 0 percent for ‘XON-209W’, a white variety, to 76.4 percent for Montero (Table 1). The percentage of onions that were functionally single centered averaged 45 percent and ranged from 14.7 percent for XON-0101 to 95.2 percent for Montero. Montero had the highest percentage of bullet and functionally single-centered bulbs in this trial.

Total yield averaged 849 cwt/acre and ranged from 721 cwt/acre for Montero to 971.4 cwt/acre for ‘Exacta’ (Table 2). Exacta, XON-0101, and Renegade were among the highest in total yield. Supercolossal-size onion yield averaged 25.6 cwt/acre and ranged from 9.2 cwt/acre for XON-209W to 47.2 cwt/acre for Exacta. Exacta and XON-0101 were among the highest in yield of supercolossal bulbs. Not considering supercolossals, colossal-size onion yield averaged 235 cwt/acre and ranged from 109.5 cwt/acre for Montero to 371 cwt/acre for Exacta. Exacta and XON-0101 had the highest colossal bulb yields.

Full Season Trial, 33 Yellow Varieties

The percentage of “bullet” single centers averaged 33.7 percent and ranged from 4 percent for Delgado to 82 percent for ‘6011’ (Table 3). Varieties 6011, Bandolero, ‘SX 7004 ON’, and ‘Sabroso’ were among the highest in percentage of onions with “bullet” single centers. Varieties 6011, SX 7004 ON, Montero, Bandolero, Sabroso, ‘Granero’, ‘Varsity’, ‘Vaquero’, ‘4001’, and ‘SVR 5819’ were among the highest in percentage of onions that were functionally single centered.

Marketable yield out of storage in January 2005 ranged from 439.9 cwt/acre for Export 151 to 1,025.7 cwt/acre for 'Ranchero' (Table 4). Ranchero, 'Sweet Perfection', and 'OLYS97-24' were among the varieties with the highest marketable yield. Supercolossal-size onion yield ranged from 2.3 cwt/acre for Sabroso to 245.6 cwt/acre for 6001. 6001, 'PX 2599', 'PX 5299', 'Harmony', 'Harvest Moon', and Ranchero were among the varieties with the highest supercolossal yield. The number of bulbs per 50 lb of super colossal onions ranged from 29.8 for 'XPH95345' to 58.0 for Sabroso. Eight yellow varieties had supercolossal bulb counts above the acceptable range (average size too small, because almost all bulbs are at the small end of the size range) for marketing as super colossals (28-36 count per 50 lb). None of the varieties had supercolossal counts below the acceptable range (averaged too big) for marketing as supercolossal. Not counting supercolossals, colossal-size onion yield ranged from 48.5 cwt/acre for Export 151 to 500.8 cwt/acre for Ranchero. Ranchero, 'Torero', PX 5299, PX 2599, OLYS97-24, Harmony, and Sweet Perfection were among the highest in colossal bulb yields.

Decomposition in storage ranged from 1.5 percent for 'Daytona' to 9 percent for 'Tequila'. No. 2 bulbs ranged from 5 cwt/acre for SX 7004ON to 100.3 cwt/acre for Harvest Moon. Bolting averaged 0.04 bolted onions per plot and occurred in only seven varieties.

Full Season Trial, Five Red Varieties

The percentage of "bullet" single centers averaged 25 percent and ranged from 10.8 percent for 'Mercury' to 46.4 percent for 'Salsa' (Table 2). The percentage of functionally single-centered onions averaged 44.6 percent and ranged from 24.2 percent for Mercury to 64.8 percent for Salsa.

Total marketable yield ranged from 389.4 cwt/acre for 'Red Fortress' to 538.8 cwt/acre for Mercury (Table 4). Colossal-size onion yield ranged from 19.4 cwt/acre for 'Red Zeppelin' to 71.7 cwt/acre for Mercury. Decomposition in storage ranged from 1.5 percent for 'Redwing' to 13.9 percent for Salsa. No. 2 bulbs ranged from 10.6 cwt/acre for Redwing to 146.1 cwt/acre for Red Fortress.

Subjective evaluation of thrips damage to red onions in storage ranged from a rating of 1.4 for Red Fortress to 3.8 for Salsa.

Full Season Trial, Five White Varieties

The percentage of "bullet" single centers averaged 22.9 percent and ranged from 15.3 percent for 'Gladstone' to 33.3 percent for 'SVR 7106' (Table 2). The percentage of functionally single-centered onions averaged 55.7 percent and ranged from 44.7 percent for 'Oro Blanco' to 76.0 percent for SVR 7106.

Total marketable yield ranged from 441.7 cwt/acre for Oro Blanco to 578.4 cwt/acre for 'SVR 5646' (Table 4). Colossal-size onion yield ranged from 80.4 cwt/acre for Oro Blanco to 217.5 cwt/acre for SVR 5646. Decomposition in storage ranged from 6.4 percent for 'Brite Knight' to 21.6 percent for Oro Blanco. No. 2 bulbs ranged from 16.0 cwt/acre for SVR 7106 to 109.6 cwt/acre for Brite Knight.

Table 1. Onion multiple-center rating and iris yellow spot virus rating for early maturing varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.
*subjective rating: 0 = no damage, 5 = total damage.

Table 2. Performance data for early maturing onion varieties harvested on August 17 and graded on

August 20, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 3. Onion multiple-center rating and iris yellow spot virus rating for long season varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.
*subjective rating: 0 = no damage, 5 = total damage.
* Thrips damage: 0 = least damage, 10 = most damage.

PUNGENCY OF SELECTED ONION VARIETIES BEFORE AND AFTER STORAGE

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Introduction

The objective of this trial was to evaluate the pungency of 12 onion varieties commonly grown in the Treasure Valley.

Methods

Varieties for pungency analysis were selected based on information provided by the seed companies on their probability of being mild (Tables 1 and 2). 'Vaquero' was included as the industry standard variety of the Treasure Valley.

The onions were grown on a Owyhee silt loam previously planted to wheat. Onion seed was planted on March 19, 2004. The procedures for growing the onions can be found in the "2004 Onion Variety Trials" report by Shock et al. in this report. Onions in the early maturity trial were lifted on August 13, topped by hand and bagged on August 17, and graded on August 20. The onions in the full-season trial were lifted on September 8 to field cure. Onions in the full season trial were topped by hand and bagged on September 15. The bags were put in storage on September 22. The storage shed was managed to maintain an air temperature of approximately 34°F. Onions from the full season trial were graded out of storage in early January 2005.

On August 25, 10 bulbs from each of 5 plots of each of 3 varieties of the early maturing trial were sent to Vidalia Labs International (Collins, GA), by UPS ground, for pyruvate and sugars analysis. On October 5, 10 bulbs from each of 5 plots of each of 9 varieties of the full season trial were sent to Vidalia Labs International for pyruvate analysis. After storage, a second sample of 10 bulbs from each plot of the 9 full season varieties was sent to Vidalia Labs on January 14, 2005.

Bulb pyruvic acid content is related to onion pungency, with the units of measurement being micromoles pyruvic acid per gram of fresh weight (µmoles/g FW). Onions with low pungency can taste sweet, because the sugar can be tasted. Onion bulbs having a pyruvate concentration of 5.5 or less are considered "sweet" according to Vidalia Labs sweet onion certification specifications. Sugars were analyzed by the Brix method.

Results

None of the early maturing varieties evaluated for pyruvate in 2004 had concentrations low enough to be considered sweet (Table 1). Of these, 'Renegade' was among the varieties with the lowest pyruvate concentration. 'Exacta' had the lowest sugar content. In 2003, variety Renegade, grown from transplants and harvested in July, had an average pyruvate concentration of 5.5 µmoles/g FW (Shock et al. 2004a).

On October 15, 2004 and January 24, 2005, none of the full season varieties had pyruvate concentrations low enough to be considered sweet (Table 2). There was no significant difference in either pyruvate concentration or sugar content between sampling dates. Varieties 'Harmony' and 'PX 5299' were among the varieties with the lowest pyruvate concentration. Varieties 'SVR 5819' and Vaquero were among the varieties with the highest sugar content. In 2003, the average pyruvate concentration of selected full season varieties was 5.3 µmoles/g FW in October and 7.9 µmoles/g FW in January, 2004 (Shock et al. 2004b).

References

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Shock, C.C., E.B.G. Feibert, and L.D. Saunders. 2004b. Pungency of selected onion varieties before and after storage. Oregon State University Agricultural Experiment Station Special Report 1055:45-46.

Table 1. Pyruvate concentration and estimated sugar concentration of selected early maturing onion varieties on September 2, 2004, Malheur Experiment Station, Ontario, OR.

Seed company	Variety	Pyruvate concentration	Sugars
		µmoles/g FW	% Brix
Seminis	Exacta	6.36	8.88
	Golden Spike	6.84	9.92
Nunhems	Renegade	5.83	9.75
Average		6.34	9.52
LSD (0.05)		0.60	0.60

Table 2. Pyruvate concentration and estimated sugar concentration of selected full season onion varieties in 2003 and 2004, Malheur Experiment Station, Ontario, OR.

Date	Company	Variety	2003 Pyruvate concentration	2003 Sugars	2004 Pyruvate concentration	2004 Sugars
			µmoles/g FW	% Brix	µmoles/g FW	% Brix
October	A. Takii	T-439	4.66	8.08	8.38	8.44
	Crookham	Harmony	6.08	8.88	7.24	8.80
	Seedworks	6011	4.90	9.04	8.04	8.64
	Seminis	Santa Fe	5.66	8.80	8.62	8.64
		PX 5299			6.63	8.25
		SVR 5819			9.88	9.48
	Nunhems	Ranchero	5.60	8.56	8.80	8.04
		Vaquero	5.62	9.00	9.10	9.00
		SX7002 ON	4.70	8.56	7.52	8.16
	Average		5.32	8.70	8.25	8.61
January	A. Takii	T-439	7.54	7.56	8.50	8.48
	Crookham	Harmony	6.40	8.72	6.60	8.56
	Seedworks	6011	8.12	8.56	8.02	8.64
	Seminis	Santa Fe	8.22	8.28	7.96	9.00
		PX 5299			8.33	8.40
		SVR 5819			8.84	9.04
	Nunhems	Ranchero	8.34	8.12	8.34	8.24
		Vaquero	8.90	8.64	8.92	8.80
		SX7002 ON	7.84	7.48	8.40	8.12
	Average		7.91	8.19	8.21	8.59
Average	A. Takii	T-439	6.10	7.82	8.44	8.46
	Crookham	Harmony	6.24	8.80	6.92	8.68
	Seedworks	6011	6.51	8.80	8.03	8.64
	Seminis	Santa Fe	6.94	8.54	8.29	8.82
		PX 5299			7.48	8.33
		SVR 5819			9.36	9.26
	Nunhems	Ranchero	6.97	8.34	8.57	8.14
		Vaquero	7.26	8.82	9.01	8.90
		SX7002 ON	6.27	8.02	7.96	8.14
Average			6.61	8.45	8.23	8.60
LSD (0.05) Date			0.08	0.17	NS	NS
LSD (0.05) Variety			0.56	0.35	0.71	0.43
LSD (0.05) Date X variety			0.79	NS	1.00	NS

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

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Introduction

In earlier trials we have shown that onion yield and grade are very responsive to careful irrigation scheduling and maintenance of soil moisture (Shock et al. 1998b, 2000). Using a high-frequency automated drip-irrigation system, the soil water potential at 8-inch depth that resulted in maximum onion yield, grade, and quality after storage was determined to be no drier than -20 kPa. It is not known whether short-term water stress, caused by irrigation errors, could result in internal bulb defects such as multiple centers and translucent scale. This trial tested the effects of short-duration water stress at different times during the season on onion single centeredness and translucent scale.

Materials and Methods

The onions were grown at the Malheur Experiment Station, Ontario, Oregon on an Owyhee silt loam previously planted to wheat. Soil analysis indicated the need for 60 lb Nitrogen (N)/acre, 100 lb phosphorus/acre, 100 lb Potassium/acre, 70 lb sulfur/acre, 2 lb copper/acre, and 1 lb boron/acre, which was broadcast in the fall. Onion (cv. ‘Vaquero’, Nunhems, Parma, ID) was planted in 2 double rows, spaced 22 inches apart (center of double row to center of double row) on 44-inch beds on March 17, 2004. The 2 rows in the double row were spaced 3 inches apart. Onion was planted at 150,000 seeds/acre. Drip tape (T-tape, T-systems International, San Diego, CA) was laid at 4-inch depth between the 2 double onion rows at the same time as planting. The distance between the tape and the double row was 11 inches. The drip tape had emitters spaced 12 inches apart and a flow rate of 0.22 gal/min/100 ft.

Immediately after planting the onion rows received 3.7 oz of Lorsban 15G® per 1,000 ft of row (0.82 lb ai/acre), and the soil surface was rolled. Onion emergence started on April 2. The trial was irrigated on April 5 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, and the water application rate was 0.10 inch/hour.

The experimental design was a randomized complete block with five replicates. There were six drip-irrigated treatments that consisted of five timings of short-duration water stress and an unstressed check. Each plot was 4 rows by 50 ft. Each plot had a ball valve allowing manual control of irrigations. The water stress was applied by turning the water off manually to all plots in a treatment until the average soil water potential at 8-inch depth for the treatment reached -60 kPa; at this point, the water to all plots in that treatment was turned on again. Each treatment was stressed once during the season. The four timings for the stress treatments were: two-leaf stage (water off May 5, water back on June 2), four-leaf stage (water off May 25, water back on June 4), early six-leaf stage (water off June 2, water back on June 11), late six-leaf stage (water off June 11, water back on June 16), and eight-leaf stage (water off June 18, water back on June 24).

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

Onion tissue was sampled for nutrient content on June 13. The roots from four onion plants in each check plot were washed with deionized water and analyzed for nutrient content by Western Labs, Parma, ID. The onions in all treatments were fertilized according to the plant nutrient analyses. Urea ammonium nitrate solution at 50 lb N/acre was applied through the drip tape on May 27 and on June 17.

Prior to onion emergence, Roundup® at 24 oz/acre was sprayed on March 29. The field had Prowl®(1lb ai/acre) broadcast on April 12 for postemergence weed control. Approximately 0.45 inch of water was applied through the minisprinkler system on April 12 to incorporate the Prowl. The field had Goal® at 0.12 lb ai/acre, Buctril® at 0.12 lb ai/acre, and Poast® at 0.28 lb ai/acre applied on May 25. Thrips were controlled with one aerial application of Warrior® on June 12, one aerial application of Warrior (0.03 lb ai/acre) plus Lannate® (0.4 lb ai/acre) on June 25, one aerial application of Warrior (0.03 lb ai/acre) plus MSR®(0.5 lb ai/acre) on July 17, and one aerial application of Warrior (0.03 lb ai/acre) plus Lannate (0.4 lb ai/acre) on July 31.

On September 9 the onions were lifted to cure. On September 15, onions in the central 40 ft of the middle 2 double rows in each plot were topped and bagged. The bags were placed into storage on September 29. The storage shed was managed to maintain an air temperature of approximately 34°F. The onions were graded on December 9. 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 (<2.25 inch), medium (2.25-3 inches), jumbo (3-4 inches), colossal (4-4.25

inches), and supercolossal (>4.25 inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading.

After grading, 50 bulbs ranging in diameter from 3.5 to 4.25 inches from each plot were rated for single centers and translucent scale. The onions were cut equatorially through the bulb middle and, if multiple centered, the long axis of the inside diameter of the first single ring was measured. These multiple-centered onions were ranked according to the diameter of the first single ring: “small doubles” have diameters less than 1.5 inch, “intermediate doubles” have diameters from 1.5 to 2.25 inches, and “blowouts” have diameters greater than 2.25 inches. Single-centered onions are classed as a “bullet”. Onions are considered functionally single centered for processing if they are a “bullet” or “small double.” The number and location of translucent scales in each bulb was also recorded.

Results and Discussion

The SWP at 8-inch depth during the stress treatments reached values lower than the planned -60 kPa (Fig. 1). Irrigations for the plots being stressed were restarted as soon as the SWP reached -60 kPa. In addition to being difficult to catch the SWP when it first reaches -60 kPa, the drip tape was located 11 inches from the soil moisture sensors, which caused a short delay between the onset of irrigations and when the wetting front reached the sensors, so that they would begin responding to the irrigations.

At no stage did water stress affect onion single centeredness or the incidence of bulbs with translucent scale in 2004 (Table 1). Single-centered “bullet” and functionally single-centered bulbs averaged 80.5 and 93.8 percent, respectively. Bulbs with translucent scale averaged 1.1 percent. In 2003, water stress at the four-leaf and six-leaf stages resulted in significantly lower single-centered and functionally single-centered bulbs than the unstressed check (Shock et al. 2004). In 2004 there were relatively few other sources of stress than those imposed by the trial treatments, suggesting a possible role of multiple sources of stress influencing multiple-centered bulbs.

The short-duration water stress in this trial did not affect onion yield or grade. The average onion yields in this trial were: 1,016.4 cwt/acre total yield, 980.5 cwt/acre marketable yield, 7.0 cwt/acre supercolossal yield, 164.3 cwt/acre colossal yield, and 786.4 cwt/acre jumbo yield. In contrast, in a previous study by Hegde (1986), onion yield and size were reduced by short-duration water stress to -85 kPa, with the onions otherwise irrigated at -45 kPa. In that study, the SWP at which the onions were irrigated was drier (-45 kPa) than in our study (-20 kPa) and the irrigation frequency was much lower, possibly causing the difference in results.

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Table 1. Onion multiple-center rating and translucent scale response to timing of water stress, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

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

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Introduction

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

Methods

Trials were conducted in two fields in 2004.

Procedures for Growing Onions in Field 1

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

Procedures for Growing Onions in Field 2

The onions were grown with furrow irrigation on an Owyhee silt loam previously planted to wheat. Onion seed ('Vaquero') was planted on March 19, 2004. The procedures can be found in "2004 Onion Variety Trials" by Shock et al. in this report.

Procedures for Surround Treatments

Onions in each field were lifted on August 9. The lifted onions were divided into plots 23 ft long. The experimental designs were randomized complete blocks with four replicates in each field. There were seven treatments: treatment 1 was untreated; 2 received one Surround application after lifting; 3 received one Surround application after lifting and one after windrowing; and 4 was treated after windrowing (Table 1). Treatments 2-4 had an application rate of 25 lb Surround/acre. Treatments 5-7 were the same as treatments 2-4, except that the application rate was 50 lb Surround/acre. The Surround was applied after lifting on August 9 with a ground sprayer and a boom with 9 nozzles spaced 10 inches apart. The Surround was applied in 102 gal water/acre with 8004 nozzles at 40 psi.

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

On August 12 the temperature probes and probed onions were removed and the onions were topped and windrowed by hand. After windrowing the temperature probes were reinserted in different onions as before. The onion windrow was sprayed with Surround using a ground sprayer with 3 nozzles spaced 10 inches apart. Application rates and specifications were the same as the initial Surround application. Since only the windrow was sprayed (one-third of the field), the application rates were reduced to 8.3 lb Surround/acre for treatments 2-4 and to 17 lb Surround/acre for treatments 5-7.

The onions were bagged on August 16 and hauled to a shed. On August 19 the onions were graded. Bulbs were separated according to quality: bulbs without blemishes (No. 1s), bulbs with sunscald damage, double bulbs (No. 2s), neck rot (bulbs infected with the fungus Botrytis allii in the neck or side), plate rot (bulbs infected with the fungus Fusarium oxysporum), and black mold (bulbs infected with the fungus Aspergillus niger). The No. 1 bulbs were graded according to diameter: small (<2.25 inches), medium (2.25-3 inches), jumbo (3-4 inches), colossal (4-4.25 inches), and supercolossal (>4.25 inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot by weighing and counting all supercolossal bulbs during grading.

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

Results and Discussion

The highest air temperature reached after lifting of the onions and before topping and windrowing was 100°F on August 11 (Table 2). The highest average bulb temperature reached after onions were lifted and before they were topped and windrowed was 129.5°F. Following the application of Surround after lifting on August 9, average maximum bulb temperatures were reduced 6-7°F compared to the untreated bulbs, but the temperature differences were statistically significant only on August 9 (Table 2, Fig. 1). Bulb temperatures for the 50-lb/acre Surround rate were slightly lower than for the 25 lb/acre rate, but the differences were not statistically significant.

The highest air temperature reached after topping and windrowing on August 12 was 99°F on August 13 (Table 3). The highest average bulb temperature reached after topping and windrowing was 129.2°F. For the onions treated with Surround after topping and windrowing, average maximum bulb temperatures were reduced by 5-6°F compared to the untreated check (Table 3, Fig. 1). After topping and windrowing, the bulb temperature differences between treatments were statistically significant for all days measured (August 12-15). After topping and windrowing, bulb temperatures for the 50-lb/acre Surround rate were slightly lower than for the 25-lb/acre rate and the differences were statistically significant on August 13, August 15, and on average.

The furrow-irrigated field (field 2) had lower marketable yield and higher yield of onions with sunscald than the drip-irrigated field (field 1, Table 4). There were no significant differences in onion yield or grade between treatments. However, in Field 2 there was a small but significant reduction in rot with increasing total amount of Surround applied (Fig. 2). In 2003, application of Surround resulted in statistically significant reductions in bulb sunscald and in increases in marketable yield (Shock et al. 2004). In 2003, the highest bulb temperature reached after lifting was 123°F and the highest bulb temperature after topping and windrowing was 121°F. These bulb temperatures were 6.5 and 8.2°F lower than the highest bulb temperatures in 2004. The higher bulb temperatures in 2004 could be related to the higher average bulb sunscald in 2004 (152 cwt/acre) compared to the average sunscald in 2003 (37 cwt/acre). The higher bulb temperatures in 2004 might also be related to the higher air temperatures reached during the 2004 trial (average of 97°F) than during the 2003 trial (average of 94°F).

References

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Table 1. Treatments applied to onions to evaluate two application rates of Surround®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 2. Maximum daily air temperature and maximum bulb temperature (°F) at 0.5-cm depth for onions treated with two rates of Surround® after lifting, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 3. Maximum daily air temperature, solar radiation, and maximum bulb temperature (°F) at 0.5-cm depth for onions treated with two rates of Surround® after topping and windrowing, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Figure 1. Onion bulb temperature over time for untreated bulbs and bulbs treated with two rates of Surround, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 4. Onion yield and grade response to application of two rates of Surround® in a drip-irrigated field (field 1) and in a furrow-irrigated field (field 2), Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Figure 2. Effect of total amount of Surround® applied on onion decomposition in a furrow-irrigated field, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

EFFECT OF ONION BULB TEMPERATURE AND HANDLING ON BRUISING

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Introduction

There is some evidence that onion handling after harvest can bruise bulbs and cause symptoms similar in appearance to translucent scale. Several shippers have suggested that the effect of handling on bruise may be influenced by bulb temperature during handling and by length of time after handling before the onions are checked. This trial tested the effect of handling 4 onion varieties at 2 temperatures on bruise and on bulb recovery after 3 days storage at 38°F.

Methods

Trial 1

Prior to evaluating variety susceptibility to bruise in January 2004, a preliminary test of the effect of drop height on bruise was conducted. Fifteen onions from mixed varieties were each dropped on their sides onto a concrete floor from heights of 0.8 m (2 ft, 7 inches), 1 m (3 ft, 4 inches), 1.2 m (3 ft, 11 inches), or 1.4 m (4 ft, 7 inches). The onions were cut equatorially and rated for damage. During rating we noted where in the bulb the damage occurred and whether the appearance was of translucent or watery, mushy rings. The damaged or bruised area had the form of a triangle (Fig. 1) which extended from the surface to the center of the bulb. When the affected scales were translucent, the damage was different from typical translucent scale in that the scales were only translucent in the bruised area.

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

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

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

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

*damage was less pronounced.

Trial 2

Onions of four varieties were randomly placed in nylon mesh bags (24 bags per variety). Given the availability of bulbs, there were 24 bulbs/bag of ‘Delgado’ (Bejo Seeds), 28 bulbs/bag of ‘Granero’, 27 bulbs/bag of ‘Vaquero’, and 30 bulbs/bag of ‘Bandolero’ (all three Nunhems). On January 13, 2005 the 24 bags of each variety were placed in 2 coolers: 12 at 32°F and 12 at 38°F. Three days later the bags were removed a few at a time from the coolers and were either not handled or handled by dropping each bulb from each bag individually on its side onto a concrete floor from a height of 1 m (3 ft, 4 inches). The spot of impact was marked on the onion bulb. After the handling treatments, half of the bags were put in a cooler at 38°F and the bulbs in the other half of the bags were immediately cut equatorially and rated for bruising. Three days after dropping, the onions in the bags stored in the cooler were rated individually for bruising. The number of bruised bulbs and the number of bruised rings in bruised bulbs was recorded. The width of the bruised area (Fig. 1) was also recorded. Rings with a watery appearance were judged to be bruised. Each treatment was replicated three times (three bags) for each variety (Table 2).

Table 2. Treatments applied to four onion varieties in January 2005.

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

8	storage at 38°F

Results

Averaged over varieties and pretreatment storage temperatures, 82.2 percent of the dropped bulbs showed bruise damage compared to 1.6 percent of the bulbs that were not dropped (Table 3). There was no significant difference in the percentage of bruised bulbs before or after storage. In 2004, the percentage of bruised bulbs was higher after storage, because the affected rings became more translucent and hence more detectable. In 2005, the damage before storage, in the form of mushy, watery rings, was easy to detect. Averaged over varieties, the percentage of dropped bulbs that showed bruise damage after storage was similar in 2004 (80.4) and in 2005 (81.6).

Averaged over varieties, there was no significant difference in percentage of bruised bulbs that were at 32°F (81 percent) when dropped compared to bulbs that were at 38°F (83.2 percent). In 2004, there was a small but significant difference between the percentage of bruised bulbs that were at 32°F (75.6 percent) when dropped and bulbs that were at 38°F (70.8 percent). Averaged over varieties, the percentage of rings that showed bruising in bruised bulbs was higher in bulbs stored at 38°F (69.9 percent) than at 32°F (64.9 percent). In 2004, the percentage of rings that showed bruising in bruised bulbs was higher in bulbs stored at 32°F (91.8 percent) than at 38°F (89.4 percent).

Averaged over temperature, variety, and handling treatment, the percentage of rings that showed bruising in bruised bulbs was lower after 3 days of storage (53.1 percent) than immediately after dropping (81.6 percent). In 2004, averaged over temperature and variety, the percentage of rings that showed bruising in bruised bulbs was also lower after 3 days of storage (82.4 percent) than immediately after dropping (98.8 percent), but the difference was smaller than in 2005. Averaged over temperature and variety, the width of the bruised area was narrower after 3 days of storage than immediately after dropping.

There was no significant difference between varieties in the percentage of bruised bulbs. Averaged over temperature and time, Granero had the highest percentage of bruised rings in bruised bulbs, and Vaquero had among the lowest percentage of bruised rings. The width of damage in bruised bulbs was widest for Granero. Granero was the only variety that did not have a lower percentage of rings that showed bruising in bruised bulbs after storage. In 2004, Vaquero had the highest percentage of bruised bulbs and Bandolero was among the lowest in percentage of bruised bulbs. In 2004, Bandolero and Vaquero were among the lowest in percentage of bruised rings in bruised bulbs.

Discussion

Onions are clearly very sensitive to bruise injury during handling, which could contribute to undesirable bulb quality at arrival for retail sales and processing. The influence of bulb temperature at dropping on bruising was small in 2004 and 2005. Bruising damage can become more evident over time after dropping, as in 2004. However, both in 2004 and 2005 a healing process started, as shown by the lower percentage of bruised rings in bruised bulbs after 3 days of storage. It would be desirable to explore the recovery time necessary for bruising injury to disappear.

There were differences between the varieties in susceptibility to bruising injury, but the differences were small and not consistent between years. The full range of variability in variety susceptibility to bruising injury is not known. Observations were made only on four varieties in this preliminary trial.

Table 3. Effect of prehandling temperature, handling, and time after handling on onion bulb bruising, Malheur Experiment Station, Oregon State University, Ontario, OR, 2005.

	Prehandling		Bruised bulbs			Affected rings in bruised bulbs			Width of damage in bruised bulbs		
	°F		-------- % --------			-------- % --------			------- cm -------		
Delgado	32	Drop	91.7	87.5	89.6	92.1	51.9	72.0	5.4	4.8	5.1
		No Drop	4.2	0.0	2.1	18.2	0.0	9.1	1.4	0.0	0.7
	38	Drop	76.4	90.3	83.4	84.8	58.1	71.5	5.8	5.0	5.4
		No Drop	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Avg	Drop	84.0	88.9	86.5	88.4	55.0	71.7	5.6	4.9	5.3
		No Drop	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Granero	32	Drop	85.7	65.5	75.6	83.6	51.3	67.5	5.9	3.9	4.9
		No Drop	1.2	3.6	2.4	25.0	17.9	21.5	1.0	1.2	1.1
	38	Drop	81.0	97.6	89.3	80.4	78.8	79.6	5.2	5.7	5.5
		No Drop	6.0	1.2	3.6	41.7	19.4	30.6	2.5	2.0	2.3
	Avg	Drop	83.3	81.5	82.4	82.0	65.1	73.6	5.6	4.8	5.2
		No Drop	3.6	2.4	3.0	33.4	18.7	26.1	1.8	1.6	1.7
Vaquero	32	Drop	84.0	72.8	78.4	80.4	40.8	60.6	5.6	5.0	5.3
		No Drop	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	38	Drop	81.5	69.1	75.3	78.9	34.1	56.5	5.6	3.3	4.5
		No Drop	6.0	1.2	3.6	41.7	19.4	30.6	2.5	2.0	2.3
	Avg	Drop	82.7	71.0	76.9	79.6	37.4	58.5	5.6	4.2	4.9
		No Drop	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Bandolero	32	Drop	77.8	83.3	80.6	76.3	42.8	59.6	5.0	4.9	5.0
		No Drop	0.0	2.2	1.1	0.0	12.8	6.4	0.0	2.0	1.0
	38	Drop	83.3	86.7	85.0	76.6	67.2	71.9	5.1	5.0	5.1
		No Drop	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Avg	Drop	80.6	85.0	82.8	76.4	55.0	65.7	5.1	4.9	5.0
		No Drop	0.0	1.1	0.6	0.0	6.4	3.2	0.0	1.0	0.5
Over all averages	32	Drop	84.8	81.6	81.1	83.1	46.7	64.9	5.5	4.7	5.1
		No Drop	1.3	1.4	1.4	10.8	7.7	9.3	0.6	0.8	0.7
	38	Drop	80.5	85.9	83.2	80.2	59.6	69.9	5.5	4.8	5.2
		No Drop	3.0	0.6	1.8	20.9	9.7	15.3	1.3	1.0	1.2
	Avg	Drop	82.7	81.6	82.2	81.6	53.1	67.4	5.5	4.7	5.1
		No Drop	2.2	1.0	1.6	15.8	8.7	12.3	0.9	0.9	0.9
LSD (0.05)	Handling				3.9			5.1			0.3
	Temperature				NS			1.7			NS
	Time				NS			1.7			0.1
	Temp. X Time				NS			2.4			NS
	Variety				NS			2.4			0.2
	Temp. X Variety				NS			3.3			0.2
	Time X Variety				NS			3.3			0.2
	Temp. X Time X Variety				NS			4.7			0.3

EVALUATION OF OVERWINTERING ONION FOR PRODUCTION IN THE TREASURE VALLEY, 2003-2004 TRIAL

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Introduction

The objective of this trial was to evaluate yellow and red onion varieties for overwintering production in the Treasure Valley. Bulb yield, grade, and pungency were evaluated. Seven yellow varieties and three red varieties were planted in August 2003 and were harvested and graded in June 2004.

Methods

The onions were grown on a field of Owyhee silt loam located northeast of the Malheur Experiment Station on Railroad Ave. between Highway 201 and Alameda Drive. Seed of 10 varieties was planted in double rows spaced 3 inches apart at 9 seeds/ft of single row on August 25, 2003. Each double row was planted on beds spaced 20 inches apart with a customized planter using John Deere Flexi Planter units equipped with disc openers. On October 21, 2003, alleys 4 ft wide were cut between plots, leaving plots 23 ft long. On October 22 the seedlings were hand thinned to a plant population of 95,000 plants/acre (6.6-inch spacing between individual onion plants). All cultural practices were performed by the grower. The experimental design was a randomized complete block with five replicates.

Onions in each plot were evaluated subjectively for maturity on June 14, 2004 by visually rating the percentage of onions with the tops down and the percent dryness of the foliage. The percent maturity was calculated as the average of the percentage of onion with tops down and the percent dryness. The number of bolted onion plants in each plot was counted.

Onions from the middle two rows in each plot were lifted, topped by hand, and bagged on June 21, 2004. The onion bags were transported to a shed at the Malheur Experiment Station. On June 23 the onions were graded.

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

Ten randomly chosen bulbs from each plot were shipped on June 25 via UPS ground to Vidalia Labs International (Collins, GA). The bulb samples were analyzed for pyruvic acid content on July 2. Bulb pyruvic acid content is a measure of pungency with the unit being micromoles pyruvic acid/g of fresh weight (µmole/g FW). Onion bulbs having a pyruvate concentration of 5.5 or less are considered sweet according to Vidalia Labs sweet onion certification specifications.

On July 6, bulbs from each plot were rated subjectively for exterior quality. Bulbs were rated for skin retention, exterior thrips damage, and rot.

Varietal differences were compared using ANOVA and least significant differences at the 5 percent probability level, LSD (0.05). Varieties were listed by company in alphabetical order. The LSD (0.05) values 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.

Results

Grower practices adequately controlled thrips during seedling emergence and early plant growth, critical phases for successful overwintering onion production in the Treasure Valley. The winter of 2003-2004 in the Treasure Valley was mild, with the lowest temperature of -1°F on January 5, 2004. In spite of that, plant populations were below the target of 95,000 plants/acre for all varieties, suggesting that a higher population should have been left after thinning. Plant populations ranged from 38,863 plants/acre for ‘Musica’ to 71,362 plants/acre for ‘T-420’ (Table 1).

Total yield averaged 440 cwt/acre and ranged from 360 cwt/acre for ‘Electric’ to 606 cwt/acre for ‘Stansa’ (Table 1). Stansa and T-420 had the highest total yield. Marketable yield averaged 391 cwt/acre and ranged from 291 cwt/acre for ‘XON-305Y’ to 545 cwt/acre for Stansa. Supercolossal-size onion yield averaged 18 cwt/acre and ranged from 2 cwt/acre for ‘MKS-816’ to 79 cwt/acre for Stansa. Stansa had the highest yield of supercolossal bulbs. Not counting supercolossals, colossal-size onion yield averaged 179 cwt/acre and ranged from 14.4 cwt/acre for ‘Desert Sunrise’ to 179 cwt/acre for Stansa. Stansa had the highest colossal bulb yields.

Maturity on June 14 ranged from 0 percent for ‘Garnet’ to 79 percent for ‘MKS-801’ (Table 2). Varieties T-420, XON-305Y, MKS-801, and MKS-816 had bulb pyruvate concentrations low enough (<5.5 µmoles/g FW) to be classified as sweet onions. MKS-801 had the lowest pyruvate concentration. Subjective evaluation of skin retention ranged from 1.6 (worst = 0) for MKS-801 to 4.4 (best = 10) for T-420. Subjective evaluation of thrips damage ranged from 5.8 (most thrips = 10) for Desert Sunrise to 1.4 (fewest thrips = 0) for ‘Hi Keeper’.

Table 1. Performance data for onion varieties planted in August 2003 and harvested in June 2004, Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 2. Maturity, pyruvate concentration, and subjective rating of exterior bulb quality: 0 = fewest and 10 = most for thrips damage and rot, 0 = worst and 10 = best for skin retention, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

WEED CONTROL IN ONION WITH POSTEMERGENCE HERBICIDES

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Introduction

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

Methods

General Procedures

Trials were conducted at the Malheur Experiment Station to evaluate experimental and registered herbicides for weed control and onion tolerance. Trials were conducted under furrow irrigation. On March 25, onions (cv. 'Vaquero', Nunhems, Parma, ID) were planted at 3.7-inch spacing in double rows on 22-inch beds. Plots were 4 rows wide and 27 ft long and arranged in a randomized complete block design with four replications. Lorsban® was applied in a 6-inch band over each double row at 3.7 oz/1,000 ft of row. Onions were sidedressed with 175 lb nitrogen (N), 30 lb phosphorus (P), 35 lb sulfate, 38 lb sulfur (S), 2 lb Zinc (Zn), 3 lb manganese (Mn), and 1 lb boron (B)/acre on June 3. Registered insecticides and fungicides were applied for thrips and downy mildew control.

Herbicide treatments were applied with a CO_2-pressurized backpack sprayer. Preemergence applications and postemergence grass herbicides were applied at 20 gal/acre at 30 psi and postemergence treatments were applied at 40 gal/acre at 30 psi. All plots were treated with a preemergence application of Roundup® (glyphosate) at 0.75 lb ai/acre plus Prow®l (pendimethalin) at 1.0 lb ai/acre on April 5 and a postemergence application of Poast® (sethoxydim) at 0.19 lb ai/acre plus crop oil concentrate (COC) (1.0% v/v) on June 16. Postemergence treatments were applied to two-leaf onions on May 6, two- to three-leaf onions on May 14, and to five-leaf onions on June 2. In the Chateau application timing trial, a separate application of Chateau was made to three-leaf onions on May 18. Weed control and onion injury were evaluated throughout the season. Onions were harvested September 16 and 17 and graded by size on October 1-4.

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).

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

Application Timings for Chateau
Chateau was applied at two rates in combination with Buctril to two-leaf or three-leaf onions. Chateau treatments were compared to Goal plus Buctril. Additional treatments included Chateau in a separate application 4 days after the Buctril application at the three-leaf application timing.

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

Results and Discussion

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

Comparison of Postemergence Chateau or Goal Combinations
Because the preemergence application of Prowl was so effective, there were no differences in weed control between any of the postemergence herbicide treatments (Table 1). Control of all species was 85 percent or greater. There were also no differences in onion injury among treatments. This is surprising as there were large differences in the herbicide rates applied for different treatments. There were a few differences in onion yields, with higher yields resulting from treatments with additional soil-active herbicides applied or with higher rates (Table 2).

Application Timings for Chateau
Treatment with Chateau combined with Buctril when applied either to two-leaf or three-leaf onions did not cause greater injury than combinations of Goal plus Buctril (Table 3). When Chateau was applied alone 4 days after Buctril was applied to three-leaf onions, injury increased significantly. By July 21 there were no differences in onion injury

among treatments. The injury caused by the delayed application of Chateau was probably related to wet cool weather that occurred after the Buctril application and prior to the Chateau application. Pigweed (redroot pigweed and Powell amaranth), common lambsquarters, hairy nightshade, and barnyardgrass control was not different among herbicide treatments and was 88 percent control or greater. Kochia control was significantly greater with treatments that contained Chateau tank-mixed with Buctril and applied at either the two-leaf or three-leaf timing compared to Buctril plus Goal. Treatments where Chateau was applied alone following the Buctril application to three-leaf onions did not control weeds better than Buctril plus Goal.

There were few significant differences in onion yields between herbicide treatments, with marketable yields ranging from 1,107 to 1,459 cwt/acre.

Addition of Nortron to Postemergence Treatments

Onion injury was not different among treatments on either evaluation date (Table 5). Pigweed, hairy nightshade, and barnyardgrass control was similar among herbicide treatments and was 89 percent or higher. The addition of Nortron at either rate to Buctril significantly increased common lambsquarters control, but control was similar to that provided by Goal plus Buctril. There was no improvement in common lambsquarters control when Nortron was added to Buctril plus Goal. Kochia control was less when Buctril was applied alone compared to treatments containing Buctril plus Nortron or Goal or both. A few of the treatments containing Nortron produced more supercolossal onions than did Buctril alone, but yields were similar to the other herbicide treatments (Table 6). Nortron is useful for improving weed control in onion but in this trial did not provide greater benefits than the currently registered herbicides.

Table 1. Onion injury and weed control from Goal® or Chateau® combinations with Buctril®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

			Injury		Weed control†				
Treatment	Rate	Timing*	5-24	6-9	Pigweed	Common lambsquarters	Hairy nightshade	Kochia	Barnyard-grass
	lb ai/acre	Leaf	%						
Untreated	--	--	--	--	--	--	--	--	--
Roundup + Prowl Buctril Buctril + Goal Goal	0.75 + 1.0 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	24	28	86	90	96	95	100
Roundup + Prowl Buctril Buctril + Goal Goal	0.75 + 1.0 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	24	20	88	85	97	95	98
Roundup + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.063 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	25	18	96	95	96	100	100
Roundup + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.094 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	29	22	93	98	100	96	98
Roundup + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 1.0 0.25 + 0.063 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	21	16	93	98	96	100	99
Roundup + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 1.0 0.25 + 0.094 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	26	21	94	99	97	100	100
Roundup + Prowl Buctril + Goal Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	20	19	96	90	99	94	100
Roundup + Prowl Buctril + Goal Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.25 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	24	17	94	90	95	96	100
Roundup + Prowl Buctril + Goal Buctril + Goal Goal	0.75 + 1.0 0.25 + 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	28	16	91	88	99	98	93

Table 1 (continued). Onion injury and weed control from Goal® or Chateau® combinations with Buctril®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

			Injury		Weed control[†]				
Treatment	Rate	Timing*	5-24	6-9	Pigweed[‡]	Common lambsquarters	Hairy nightshade	Kochia	Barnyard-grass
	lb ai/acre	Leaf	%						
Roundup + Prowl	0.75 + 1.0	PRE	28	19	90	93	94	100	95
Buctril + Goal	0.25 + 0.25	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	25	18	95	97	97	88	100
Buctril + Chateau	0.125 + 0.047	2-leaf							
Buctril + Chateau	0.25 + 0.047	3-leaf							
Goal	0.25	5-leaf							
Roundup + Dacthal + Prowl	0.75 +	PRE	27	21	97	92	100	96	100
Buctril + Chateau	7.5 + 0.6	2-leaf							
Buctril + Goal	0.25 + 0.094	3-leaf							
Goal	0.125 + 0.25	5-leaf							
	0.25								
Roundup + Dacthal + Prowl	0.75 + 7.5 + 0.6	PRE	27	18	96	98	100	100	100
Buctril + Chateau	0.125 + 0.094	2-leaf							
Buctril + Goal	0.125 + 0.25	3-leaf							
Goal	0.25	5-leaf							
Roundup + Dacthal + Prowl	0.75 + 7.5 + 0.6	PRE	24	20	96	100	98	100	95
Buctril + Chateau	0.25 + 0.094	2-leaf							
Buctril + Goal	0.125 + 0.125	3-leaf							
Goal	0.25	5-leaf							
LSD (P = 0.05)	--	--	NS	NS	NS	NS	NS	NS	NS

*Preemergence (PRE) treatments were applied on April 5, two-leaf (2-leaf) on May 6, three-leaf (3-leaf) on May 14, and five-leaf (5-leaf) on June 2.
[†]Weed-control ratings were taken September 2.
[‡]Pigweed is a combination of redroot pigweed and Powell amaranth.

Table 2. Onion yield in response to Goal® or Chateau® combinations with Buctril®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Rate	Timing*	Onion yield‡					
			Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
	lb ai/acre	Leaf	cwt/acre					
Untreated	--	--	0	0	0	0	0	0
Roundup + Prowl Buctril Buctril + Goal Goal	0.75 + 1.0 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	5	28	626	345	30	1,029
Roundup + Prowl Buctril Buctril + Goal Goal	0.75 + 1.0 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	4	13	527	540	150	1,229
Roundup + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.063 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	7	16	481	522	141	1,160
Roundup + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.094 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	6	17	559	510	123	1,208
Roundup + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 1.0 0.25 + 0.063 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	4	18	580	453	115	1,167
Roundup + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 1.0 0.25 + 0.094 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	5	17	562	490	207	1,275
Roundup + Prowl Buctril + Goal Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	7	48	595	348	111	1,101
Roundup + Prowl Buctril + Goal Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.25 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	3	13	497	524	181	1,216
Roundup + Prowl Buctril + Goal Buctril + Goal Goal	0.75 + 1.0 0.25 + 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	8	20	583	361	78	1,041

Table 2 (continued). Onion yield in response to Goal® or Chateau® combinations with Buctril®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Rate	Timing*	Onion yield‡ Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
	lb ai/acre	Leaf	cwt/acre					
Roundup + Prowl Buctril + Goal Buctril + Goal Goal	0.75 + 1.0 0.25 + 0.25 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	5	16	502	592	167	1,277
Roundup + Prowl Buctril + Chateau Buctril + Chateau Goal	0.75 + 1.0 0.125 + 0.047 0.25 + 0.047 0.25	PRE 2-leaf 3-leaf 5-leaf	5	23	600	441	128	1,192
Roundup + Dacthal + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 7.5 + 0.6 0.25 + 0.094 0.125 + 0.25 0.25	PRE 2-leaf 3-leaf 5-leaf	3	18	461	552	207	1,238
Roundup + Dacthal + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 7.5 + 0.6 0.125 + 0.094 0.125 + 0.25 0.25	PRE 2-leaf 3-leaf 5-leaf	4	15	450	596	225	1,285
Roundup + Dacthal + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 7.5 + 0.6 0.25 + 0.094 0.125 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	4	18	484	552	168	1,222
LSD (P = 0.05)	--	--	5	18	185	180	122	193

*Preemergence (PRE) treatment applied on April 5, two-leaf (2-leaf) on May 6, three-leaf (3-leaf) on May 14, and five-leaf (5-leaf) on June 2.
†Onions were harvested on September 16 and 17.

Table 3. Weed control and onion injury in response to Chateau® application timings, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

			Injury		Weed control[†]				
Treatment	Rate	Timing*	5-24	6-21	Pigweed[‡]	Common lambsquarters	Hairy nightshade	Kochia	Barnyard-grass
	lb ai/acre	Leaf	%						
Untreated	--	--	--	--	--	--	--	--	--
Roundup + Prowl	0.75 + 1.0	PRE	24	16	89	90	97	72	100
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	26	19	96	90	100	96	99
Buctril + Chateau	0.125 + 0.063	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	26	21	94	89	100	96	100
Buctril + Chateau	0.125 + 0.094	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	29	21	97	88	100	99	98
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Chateau	0.25 + 0.063	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	29	21	91	91	99	93	100
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Chateau	0.25 + 0.094	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	34	20	92	89	100	77	100
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril	0.25	3-leaf							
Chateau	0.063	3-leaf (S)							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	36	21	92	91	98	82	100
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril	0.25	3-leaf							
Chateau	0.094	3-leaf (S)							
Goal	0.25	5-leaf							
LSD (P = 0.05)	--	--	5	NS	NS	NS	NS	15	NS

*Preemergence (PRE) treatments were applied on April 5, two-leaf (2-leaf) on May 6, three-leaf (3-leaf) on May 14, three-leaf separate (3-leaf (S)) on May 18, and five-leaf (5-leaf) on June 2.
[†]Weed control ratings were taken September 2.
[‡]Pigweed is a combination of redroot pigweed and Powell amaranth.

Table 4. Onion yield in response to Chateau® application timings, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

			Onion yield†					
Treatment	Rate	Timing*	Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
	lb ai/acre	Leaf	cwt/acre					
Untreated	--	--	0	0	0	0	0	0
Roundup + Prowl Buctril + Goal Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	4	18	639	385	75	1,117
Roundup + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.063 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	4	16	519	535	110	1,179
Roundup + Prowl Buctril + Chateau Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.094 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	4	28	592	386	87	1,093
Roundup + Prowl Buctril + Goal Buctril + Chateau Goal	0.75 + 1.0 0.125 + 0.125 0.25 + 0.063 0.25	PRE 2-leaf 3-leaf 5-leaf	4	22	602	501	90	1,215
Roundup + Prowl Buctril + Goal Buctril + Chateau Goal	0.75 + 1.0 0.125 + 0.125 0.25 + 0.094 0.25	PRE 2-leaf 3-leaf 5-leaf	2	21	640	713	86	1,459
Roundup + Prowl Buctril + Goal Buctril Chateau Goal	0.75 + 1.0 0.125 + 0.125 0.25 0.063 0.25	PRE 2-leaf 3-leaf 3-leaf (S) 5-leaf	6	30	661	345	70	1,107
Roundup + Prowl Buctril + Goal Buctril Chateau Goal	0.75 + 1.0 0.125 + 0.125 0.25 0.094 0.25	PRE 2-leaf 3-leaf 3-leaf (S) 5-leaf	6	30	584	423	109	1,145
LSD (P = 0.05)	--	--	2	18	99	302	64	333

*Preemergence (PRE) treatments were applied on April 5, two-leaf (2-leaf) on May 6, three-leaf (3-leaf) on May 14, three-leaf separate (3-leaf (S)) on May 18, and five-leaf (5-leaf) on June 2.

†Onions were harvested on September 16 and 17.

Table 5. Onion injury and weed control in response to the addition of Nortron® to postemergence applications of Buctril® and Goal®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Rate	Timing*	Injury		Weed control[†]				
			5-24	6-9	Pigweed[‡]	Common lambsquarters	Hairy nightshade	Kochia	Barnyard-grass
	lb ai/acre	Leaf	%						
Untreated	--	--	--	--	--	--	--	--	--
Roundup + Prowl Buctril Buctril + Goal Goal	0.75 + 1.0 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	20	18	89	89	100	76	100
Roundup + Prowl Buctril + Goal Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.125 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	25	21	93	95	100	89	100
Roundup + Prowl Buctril + Nortron Buctril + Goal + Nortron Goal	0.75 + 1.0 0.125 + 0.25 0.25 + 0.125 + 0.25 0.25	PRE 2-leaf 3-leaf 5-leaf	23	16	100	100	97	95	100
Roundup + Prowl Buctril + Nortron Buctril + Goal + Nortron Goal	0.75 + 1.0 0.125 + 0.5 0.25 + 0.125 + 0.5 0.25	PRE 2-leaf 3-leaf 5-leaf	27	22	90	100	100	97	100
Roundup + Prowl Buctril + Goal + Nortron Buctril + Goal + Nortron Goal	0.75 + 1.0 0.125 + 0.125 + 0.25 0.25 + 0.125 + 0.25 0.25	PRE 2-leaf 3-leaf 5-leaf	28	23	93	93	100	94	100
Roundup + Prowl Buctril + Goal + Outlook Buctril + Goal + Nortron Goal	0.75 + 1.0 0.125 + 0.125 + 0.84 0.25 + 0.125 + 0.25 0.25	PRE 2-leaf 3-leaf 5-leaf	25	18	100	100	100	98	100
Roundup + Prowl Buctril + Goal + Nortron Buctril + Goal + Nortron Buctril + Goal	0.75 + 1.0 0.125 + 0.125 + 0.5 0.25 + 0.125 + 0.5 0.125 + 0.25	PRE 2-leaf 3-leaf 5-leaf	28	24	97	99	97	100	97
LSD (P = 0.05)	--	--	NS	NS	NS	7	NS	13	NS

*Preemergence (PRE) treatments were applied on April 5, two-leaf (2-leaf) on May 6, three-leaf (3-leaf) on May 14, and five-leaf (5-leaf) on June 2.
[†]Weed control ratings were taken September 2.
[‡]Pigweed is a combination of redroot pigweed and Powell amaranth.

Table 6. Onion yield in response to the addition of Nortron® to postemergence applications of Buctril® and Goal®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Rate	Timing*	Onion yield†					
			Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
	lb ai/acre	Leaf	cwt/acre					
Untreated	--	--	0	0	0	0	0	0
Roundup + Prowl	0.75 + 1.0	PRE	8	45	689	225	12	971
Buctril	0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	7	37	609	354	65	1,066
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	6	29	693	349	60	1,130
Buctril + Nortron	0.125 + 0.25	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.25	3-leaf						
Goal	0.25	5-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	3	18	597	424	111	1,150
Buctril + Nortron	0.125 + 0.5	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.5	3-leaf						
Goal	0.25	5-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	4	33	640	363	72	1,107
Buctril + Goal + Nortron	0.125 + 0.125 + 0.25	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.25	3-leaf						
Goal	0.25	5-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	4	17	614	475	117	1,223
Buctril + Goal + Outlook	0.125 + 0.125 + 0.84	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.25	3-leaf						
Goal	0.25	5-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	8	21	662	440	97	1,219
Buctril + Goal + Nortron	0.125 + 0.125 + 0.5	2-leaf						
Buctril + Goal + Nortron	0.25 + 0.125 + 0.5	3-leaf						
Buctril + Goal	0.125 + 0.25	5-leaf						
LSD (P = 0.05)	--	--	4	16	113	237	66	278

*Preemergence (PRE) treatment applied on April 5, two-leaf (2-leaf) on May 14, three-leaf (3-leaf) on May 18, and five-leaf (5-leaf) on June 2.
†Onions were harvested on September 16 and 17.

SOIL-ACTIVE HERBICIDE APPLICATIONS FOR WEED CONTROL IN ONION

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Introduction

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

Methods

General Procedures

A trial was conducted at the Malheur Experiment Station under furrow irrigation. On March 25, onions (cv. 'Vaquero', Nunhems, Parma, ID) were planted at 3.7-inch spacing in double rows on 22-inch beds. Plots were 4 rows wide and 27 ft long and arranged in a randomized complete block design with 4 replicates. Lorsban® was applied in a 6-inch band over each double row at 3.7 oz/1,000 ft of row. Onions were sidedressed with 175 lb nitrogen, 30 lb phosphorus, 35 lb sulfate, 38 lb elemental sulfur, 2 lb zinc, 3 lb manganese, and 1 lb boron/acre on June 3. Registered insecticides and fungicides were applied for thrips and downy mildew control.

Preemergence (PRE) applications of Prowl® (pendimethalin), Nortron® (ethofumesate), and Outlook® (dimethenamid-P) in combination with Roundup (glyphosate) were evaluated for weed control and onion tolerance. Each product was evaluated at two rates. Combinations of Prowl with Nortron or Outlook were also evaluated. Prowl and Prowl H_20® (a new water-based formulation) were also applied to onions at the flag leaf stage following Roundup applied PRE. Prowl H_20 was also combined with Outlook applied at the flag leaf stage following a PRE application of Roundup. Preemergence treatments and other applications of soil-active herbicides were compared to plots where only Roundup was applied preemergence.

Herbicide treatments were applied with a CO_2-pressurized backpack sprayer. Preemergence applications were applied at 20 gal/acre at 30 psi. Postemergence applications were applied at 40 gal/acre at 30 psi. Preemergence treatments were applied on April 5, two-leaf on May 6, three-leaf on May 14, and five-leaf on June 2.

All plots received Poast® (sethoxydim) at 0.19 lbs ai/acre plus crop oil concentrate (COC) (1 qt/acre) on June 16 to control grasses. Weed control and onion injury were evaluated throughout the season. Onions were harvested September 16 and 17 and graded by size on October 1-4.

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).

Results and Discussion

Preemergence and postemergence treatments were effective because of rain and actively growing weeds at the time herbicides were applied. Injury was similar among treatments except for plots treated with a tank mixture of Buctril, Outlook, and Chateau, which had significantly more injury than all other treatments on May 24 and at the later evaluation on June 9 (Table 1). Pigweed (redroot pigweed and Powell amaranth) control was similar among herbicide treatments and ranged from 84 to 99 percent. Common lambsquarters control was improved with preemergence applications of Prowl compared to plots treated only with Roundup PRE. Outlook and Nortron did not significantly increase common lambsquarters control compared to Roundup alone. Hairy nightshade control was greater than 90 percent and barnyardgrass greater than 96 percent for all herbicides. Kochia control was significantly greater with PRE Prowl or Nortron compared to Outlook. However, the high rate of Outlook improved kochia control compared to Roundup alone PRE. This year, delaying Prowl or Prowl plus Outlook combinations until the flag leaf stage provided similar control to preemergence applications. If these treatments are as effective as the PRE applications, then applications to flag leaf onions provide an increased level of crop safety compared to PRE applications. Treatments with Prowl applied PRE or to flag leaf onions followed by applications of Outlook to two-leaf onions also effectively controlled all weeds. The Prowl label allows applications to flag leaf onions and the Outlook label allows applications to two-leaf onions.

Roundup alone PRE and Roundup plus Outlook (0.66 lb ai/acre) produced higher medium onion yields and lower colossal, total, and marketable onion yields compared to all the other treatments (Table 2). The combination of Prowl plus Outlook PRE had among the lowest number of onion bulbs per acre and was less than plots with Roundup alone PRE or applications of Prowl made to flag leaf onions. This result illustrates the potential to reduce onion stand with PRE applications of soil-active herbicides. Even with the reduced number of onion bulbs, this treatment produced yields similar to all other treatments. Only plots with reduced weed control had significantly lower yields. The increased weed control and subsequent increase in onion yields from plots receiving a PRE or flag leaf application of a soil-active herbicide demonstrates the importance of soil-active herbicides for reducing weed germination and growth prior to when postemergence herbicide applications can be made.

Table 1. Onion injury and weed control in response to applications of Outlook®, Nortron®, and Prowl®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Rate	Timing*	Injury 5-24	Injury 6-9	Weed control‡ Pigweed†	Common lambsquarters	Hairy nightshade	Kochia	Barnyardgrass
	lb ai/acre	Leaf	%						
Untreated	--	--	--	--	--	--	--	--	--
Roundup + Outlook	0.75 + 0.656	PRE	25	16	87	77	100	73	100
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Outlook	0.75 + 0.843	PRE	25	17	95	88	100	85	100
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Nortron	0.75 + 1.0	PRE	26	19	88	85	91	96	98
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Nortron	0.75 + 2.0	PRE	27	16	93	90	100	100	100
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	25	16	98	96	100	95	98
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.5	PRE	26	17	95	98	100	99	100
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup	0.75	PRE	25	16	84	77	98	69	99
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl + Nortron	0.75 + 1.0 + 1.0	PRE	26	16	99	100	100	99	97
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl + Outlook	0.75 + 1.0 + 0.843	PRE	26	18	97	100	95	98	100
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							

Table 1 (continued). Onion injury and weed control in response to applications of Outlook®, Nortron®, and Prowl®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Rate	Timing*	Injury 5-24	Injury 6-9	Weed control† ‡Pigweed	Common lambsquarters	Hairy nightshade	Kochia	Barnyardgrass
	lb ai/acre	Leaf	------	------	------	%	------	------	------
Roudup	0.75	PRE	26	17	96	93	99	97	100
Prowl + Outlook	1.0 + 0.843	flag							
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup	0.75	PRE	26	18	95	92	100	88	100
Prowl H2O + Outlook	1.0 + 0.843	flag							
Buctril + Goal	0.125 + 0.125	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup	0.75	PRE	25	16	88	83	97	100	100
Prowl	1.0	flag							
Buctril + Goal + Outlook	0.125 + 0.125 + 0.843	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup	0.75	PRE	26	17	92	92	100	100	100
Prowl H2O	1.0	flag							
Buctril + Goal + Outlook	0.125 + 0.125 + 0.843	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	24	17	97	98	100	100	99
Buctril + Goal + Outlook	0.125 + 0.125 + 0.843	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
Roundup + Prowl	0.75 + 1.0	PRE	39	27	98	100	100	100	96
Buctril + Chateau + Outlook	0.125 + 0.063 + 0.843	2-leaf							
Buctril + Goal	0.25 + 0.125	3-leaf							
Goal	0.25	5-leaf							
LSD (0.05)	--	--	2	3	12	12	6	10	3

*Preemergence (PRE) treatments were applied on April 5, two-leaf (2-leaf) on May 6, three-leaf (3-leaf) on May 14, and five-leaf (5-leaf) on June 2.
†Weed control was evaluated on September 2.
‡Pigweed is a combination of redroot pigweed and Powell amaranth.

Table 2. Onion yield in response to applications of Outlook®, Nortron®, and Prowl®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Rate	Timing*	Onion yield†					
			Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
	lb ai/acre	Leaf	cwt/acre					
Untreated	--	--	--	--	--	--	--	--
Roundup + Outlook	0.75 + 0.656	PRE	8	59	650	151	25	884
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						
Roundup + Outlook	0.75 + 0.843	PRE	9	23	726	340	22	1111
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						
Roundup + Nortron	0.75 + 1.0	PRE	9	31	624	369	60	1085
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						
Roundup + Nortron	0.75 + 2.0	PRE	5	32	633	379	61	1105
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						
Roundup + Prowl	0.75 + 1.0	PRE	9	22	695	412	70	1199
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						
Roundup + Prowl	0.75 + 1.5	PRE	7	23	640	357	73	1092
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						
Roundup	0.75	PRE	11	59	678	128	10	874
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						
Roundup + Prowl + Nortron	0.75 + 1.0 + 1.0	PRE	11	23	555	498	101	1176
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						
Roundup + Prowl + Outlook	0.75 + 1.0 + 0.843	PRE	4	20	543	423	110	1095
Buctril + Goal	0.125 + 0.125	2-leaf						
Buctril + Goal	0.25 + 0.125	3-leaf						
Goal	0.25	5-leaf						

Table 2 (continued). Onion yield in response to applications of Outlook®, Nortron®, and Prowl®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Rate	Timing*	Onion yield†					
			Small	Medium	Jumbo	Colossal	S. Colossal	Marketable
	lb ai/acre	Leaf	cwt/acre					
Untreated	--	--	--	--	--	--	--	--
Roundup Prowl + Outlook Buctril + Goal Buctril + Goal Goal	0.75 1.0 + 0.843 0.125 + 0.125 0.25 + 0.125 0.25	PRE flag 2-leaf 3-leaf 5-leaf	7	33	599	382	83	1097
Roundup Prowl H2O + Outlook Buctril + Goal Buctril + Goal Goal	0.75 1.0 + 0.843 0.125 + 0.125 0.25 + 0.125 0.25	PRE flag 2-leaf 3-leaf 5-leaf	7	28	676	348	70	1122
Roundup Prowl Buctril + Goal + Outlook Buctril + Goal Goal	0.75 1.0 0.125 + 0.125 + 0.843 0.25 + 0.125 0.25	PRE flag 2-leaf 3-leaf 5-leaf	10	31	647	391	64	1132
Roundup Prowl H2O Buctril + Goal + Outlook Buctril + Goal Goal	0.75 1.0 0.125 + 0.125 + 0.843 0.25 + 0.125 0.25	PRE flag 2-leaf 3-leaf 5-leaf	6	30	683	370	61	1144
Roundup + Prowl Buctril + Goal + Outlook Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.125 + 0.843 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	6	23	582	491	126	1221
Roundup + Prowl Buctril + Chateau + Outlook Buctril + Goal Goal	0.75 + 1.0 0.125 + 0.063 + 0.843 0.25 + 0.125 0.25	PRE 2-leaf 3-leaf 5-leaf	5	28	594	433	67	1122
LSD (0.05)	--	--	6	20	111	181	57	188

*Preemergence (PRE) treatments were applied on April 5, two-leaf (2-leaf) on May 6, three-leaf (3-leaf) on May 14, and five-leaf (5-leaf) on June 2.
†Onions were harvested on September 16 and 17.

INSECTICIDE TRIALS FOR ONION THRIPS (*THRIPS TABACI*) CONTROL – 2004

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Ontario, OR

Introduction

During the past 4 years alternative insecticides have demonstrated superior control of onion thrips when compared to conventional insecticides. Alternative insecticides in this trial are azadirachtin (Aza-Direct® and Ecozin®) an extract from the neem tree (*Azadirachia indica*, A. Juss.), and spinosad (Success®), a bacterial fermentation product. Conventional insecticides are the currently registered products in the synthetic pyrethroid (Warrior®, Mustang®), organophosphate (parathion, malathion, Guthion®, Diazinon), and carbamate (Lannate®, Vydate®) classes. Different rates and combinations of these insecticides were tested for efficacy against onion thrips.

Materials and Methods

A 36.7-ft-wide by 500-ft long block was planted to onion (cv. 'Vaquero', Nunhems, Parma, ID) on March 23, 2004. The onions were planted as 2 double rows on a 44-inch bed. The double rows were spaced 2 inches apart. The seeding rate was 137,000 seeds/acre. Lorsban 15G® was applied in a 6-inch band over each double row at planting at a rate of 3.7 oz/1,000 ft of row for onion maggot control. Water was applied by furrow irrigation. The plots were 7.3 ft wide (2 beds) by 25 ft long and were replicated 4 times.

There were 14 treatments as outlined in Table 1. Acephate is an older insecticide that is now manufactured by several companies. It is not currently registered for use on onions.

Insecticide applications were made with a CO_2-pressurized plot sprayer with 4 nozzles spaced 19 inches apart. All treatments were made with water as a carrier at 38.9 gal/acre. Thrips counts were made weekly through the growing season by counting the total number of thrips on 20 plants.

The onion bulbs were harvested by hand on September 10 and graded on October 11. The plot area harvested was 20 ft of the center 2 double rows.

Treatment differences were compared using ANOVA and least significant differences at the 5 percent probability level, LSD (0.05). Means were also compared using Duncan's multiple range test.

Results and Discussion

Thrips populations in June were fairly high (Fig.1). The acephate treatments provided the best thrips control. Table 2 contains yield and grade information. All of the yield classes had significant differences except for medium-size onions. Acephate treatments had the highest yield of supercolossal plus colossal bulbs at both the 8.0-oz and 16.0-oz rate, and the 6.0 oz rate had the highest yield of colossal bulbs. The Aza Direct plus Success (10.0 oz) had the overall highest yield followed by treatment 13, which was a combination of Penncap M plus MSR® and Warrior plus MSR. Acephate at the 6.0-oz rate also produced high yields.

Aza-Direct by itself produced the lowest yields, followed by the late June and mid-July applications of Warrior plus MSR and Warrior plus Lannate (treatment 2). Compost tea by itself was not better than the untreated check. Aza-Direct plus the 6.0-oz rate of Success was not better than the untreated check, whether applied as a weekly spray mix or alternated weekly.

The iris yellow spot virus infected the plot area late in the season. The treatments were evaluated for resistance to disease expression and the data are shown in Table 3. Generally, the treatments with the highest yields had less incidence of the disease although the correlation was not very strong.

Conclusions

Azadirect (20 oz) plus Success applied at the 10.0-oz rate (treatment 14) and acephate at the 8.0-oz rate (treatment 12) were the best treatments. Neither Success or acephate is currently registered for use on onions although a section 18 emergency registration for Success was granted in 2004 and is anticipated again in 2005.

There were significant differences between treatments in all onion size classes except mediums.

Table 1. Insecticides evaluated for thrips control, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment no.	Insecticide applied	Formulated product	Treatment date			
		Rate/acre	6/7	6/28	7/16	7/29
1	Aza-Direct	20.0 oz	X	X	X	X
2	Warrior + MSR	3.8 oz 2.0 pt		X		
	Warrior + Lannate	3.8 oz 3.0 pt			X	
3	Untreated check					
4	Aza-Direct	20.0 oz	X		X	
	Success	6.0 oz		X		X
5	Compost Tea	4.0 gal	X	X	X	X
6	Warrior	3.8 oz	X			
	Warrior + Lannate	3.8 oz 3.0 pt				X
7	Aza-Direct + Success	20.0 oz 6.0 oz	X	X	X	X
8	Acephate	16.0 oz	X	X	X	X
9	Success	6.0 oz	X		X	
10	Success	6.0 oz	X	X	X	X
11	Warrior	3.8 oz	X			
	Warrior + MSR	3.8 oz 2.0 pt		X		
	Warrior + Lannate	3.8 oz 3.0 pt			X	
12	Acephate	8.0 oz	X	X	X	X
13	Penncap M + MSR	2.0 pt 2.0 pt	X	X	X	
	Warrior + MSR	3.8 oz 2.0 pt				X
14	Aza-Direct + Success	20.0 oz 10.0 oz	X	X	X	X

Table 2. Effects of different thrips treatments on onion yield and grade, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment No.	Medium	Jumbo	Colossal	Super-colossal	Colossal + S-Col.	Jumbo + Col. + S-Col.	Total Yield
	--cwt/acre--						
1	18.2	464.2	220.2	10.7	230.9	695.1	713.3
2	13.2	394.0	278.9	39.4	318.3	712.3	725.5
3	11.5	475.3	241.9	44.2	286.1	761.4	773.0
4	12.4	399.8	322.1	43.7	365.8	765.6	778.0
5	9.9	501.5	263.3	36.4	299.7	801.2	811.1
6	13.0	432.0	318.9	50.7	369.6	801.6	814.6
7	7.4	351.0	351.1	107.3	458.5	809.5	816.9
8	7.7	296.5	379.3	160.0	539.2	835.7	843.4
9	13.3	435.8	346.2	87.2	433.3	869.1	882.4
10	13.2	388.8	398.9	89.6	488.4	877.2	890.3
11	11.0	398.0	411.4	85.9	497.2	895.2	906.3
12	6.2	260.0	489.2	165.2	654.4	914.4	920.6
13	14.1	486.3	382.3	42.4	424.7	911.1	925.2
14	13.3	431.4	392.5	105.6	498.1	929.6	942.9
LSD (0.05)	ns	133.6	110.8	65.7	142.0	133.6	132.1

Table 3. Evaluation of iris yellow spot virus disease severity with different insecticide treatments for the thrips vector, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment Number	Iris yellow spot virus severity
	0 = dead; 5 = no injury
1	2.8
2	2.0
3	2.3
4	2.3
5	2.3
6	2.3
7	4.0
8	4.0
9	2.8
10	3.8
11	3.2
12	4.0
13	3.0
14	3.8
LSD (0.05)	0.6

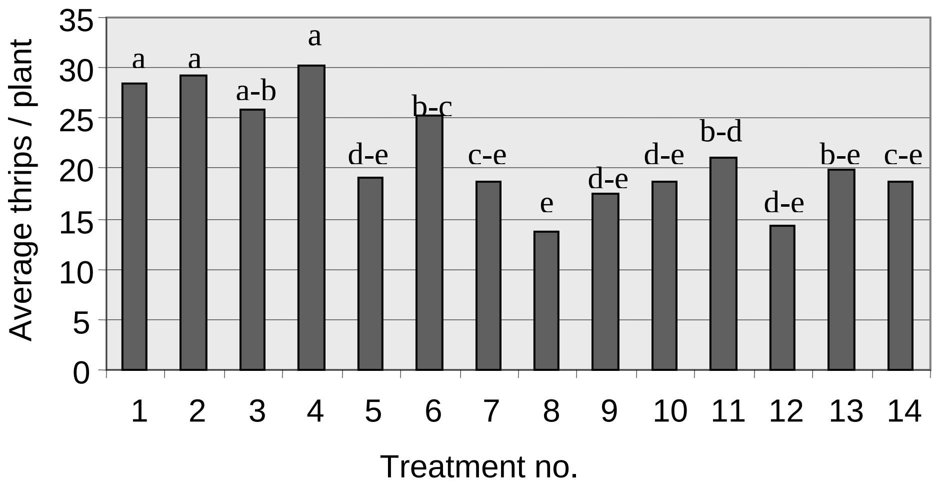

Figure 1. Treatment effects on thrips populations during June, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

A TWO-YEAR STUDY ON VARIETAL RESPONSE TO AN ALTERNATIVE APPROACH FOR CONTROLLING ONION THRIPS (*THRIPS TABACI*) IN SPANISH ONIONS

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Ontario, OR, 2003-2004

Introduction

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

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

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

Materials and Methods

A 1.5-acre field was planted to the onion varieties Vaquero, ‘Flamenco’, and ‘Redwing’ (cv. Vaquero, Flamenco, Nunhems, Parma, ID; Redwing, Bejo Seeds, Oceano, CA) in a split plot design on March 14, 2003 and March 23, 2004. Vaquero is a yellow variety while Redwing and Flamenco are red varieties. Red varieties are generally assumed to be more attractive to thrips than yellow varieties. The onion varieties were planted as 2 double rows on a 44-inch bed. The double rows were spaced 2 inches apart. The seeding rate was 137,000 seeds/acre. Lorsban 15G® was applied in a 6-inch band over each row at planting at a rate of 3.7 oz/1000 ft of row for onion maggot control. Water was applied by furrow irrigation. The field was divided into plots 37 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 as described previously (Jensen et al. 2003a, 2003b). The grower standard treatment included Warrior® (lambda-cyhalothrin), MSR® (oxydemeton-methyl), and Lannate® (methomyl). The untreated check did not receive any treatments for thrips control. The alternative treatment included straw mulch applied to the center of the bed plus Success® (spinosad), and Aza-Direct® (azadirachtin).

Insecticide treatments were applied 7-10 days apart during the growing season (Table 1). All insecticides were sprayed in water at 31 gal/acre in 2003 and 39 gal/acre in 2004. Straw was applied only between the irrigation furrows on top of the beds to avoid confounding irrigation effects with thrips effects. The straw was applied on May 1, 2003 at a rate of 1,080 lb/acre. Straw was not applied in 2004 because results in 2003 suggested it was not enhancing thrips control.

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

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

Treatment differences were compared using ANOVA and least significant differences at the 5 percent probability level, LSD (0.05). Means were also compared using Duncan's multiple range test.

Results and Discussion

Weekly thrips populations are compared in Figure 1. The alternative program had a significantly lower average thrips population than the untreated check in both years (Fig. 2). Visual damage to the foliage was observed with the variety Vaquero in 2004 but not in 2003. Flamenco showed severe foliage damage from thrips feeding. The visual thrips damage to Redwing appeared intermediate between Vaquero and Flamenco. Flamenco is less vigorous than Redwing and more thrips damage would be expected.

There were no yield differences between any of the treatments with Vaquero in 2003 but the alternative treatment produced significantly more colossal- and super-colossal-sized bulbs in 2004 (Table 2).

Redwing significantly increased yield of colossal-sized bulbs with the alternative treatment both years compared to both the standard and untreated check and significantly increased in total yield in 2003 compared to the untreated check (Table 3).

Flamenco responded to the alternative treatments with significantly less medium-size yield and higher jumbo and colossal yield compared to the untreated check in 2003 (Table 4). There was a trend towards higher total yield and larger bulb size compared to the standard treatment but this was only significant in the colossal size class in 2003. The alternative plus standard treatments produced higher total yields than the untreated control in 2004.

Predator populations (Fig. 3) were significantly higher in the alternative and untreated check treatments than in the standard treatment. The predator population consisted mostly of spiders, big-eyed bugs, minute pirate bugs, damsel bugs, lacewings and lady bird beetles.

The 2004 season experienced an epidemic of iris yellow spot virus (IYSV) in the trial area and surrounding fields. The IYSV is a new disease currently spreading to most production areas of the United States and the world. Onion thrips are the vector, so this trial gave the opportunity to evaluate the alternative program for IYSV control (Table 5). The treatments grown under the alternative treatment were healthier and showed significantly less virus damage than the standard insecticide treatment or the untreated check.

Red onions often exhibit thrips scarring when placed in storage due to continued feeding by the insects. The alternative treatment produced significantly fewer damaged bulbs compared to the untreated check with the Redwing variety, and a similar though not significant trend with Flamenco (Table 6). Averaged over treatment, Redwing had less thrips injury than Flamenco.

Conclusion

The alternative treatments were equal to or in some cases significantly better than the standard insecticide program. There was a general trend towards higher yields in the larger bulb classes, which gives a higher return to the grower. The alternative program produced less thrips damage to red onions in storage and reduced the incidence of iris yellow spot virus.

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Table 1. Application dates for thrips control on two red and one yellow onion variety, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003-2004.

Application date	Standard insecticide treatment		Alternative insecticide treatment	
	Insecticides applied	Rate/acre	Insecticides applied	Rate/acre
		2003		
June 7	Warrior	3.84 oz.	Aza-Direct	20.0 oz.
			Success	10.0 oz.
June 14	--------	-------	Aza-Direct	20.0 oz.
			Success	10.0 oz.
June 25	Warrior	3.84 oz.	--------	--------
	Lannate	3.0 oz.		
July 3	-------	-------	Aza-Direct	20.0 oz.
			Success	10.0 oz.
July 7	Warrior	3.84 oz.	--------	-------
	MSR	2.0 pt.		
July 11	------	------	Aza-Direct	20.0 oz.
			Success	10.0 oz
July 25	Warrior	3.84 oz.	------	-------
	Lannate	3.0 pt.		
July 29	--------	-------	Aza-Direct	20.0 oz
			Success	10.0 oz.
		2004		
June 6	Warrior	3.84 oz.	Aza-Direct	20.0 oz.
	MSR	2.0 pt.	Success	10.0 oz.
June 16	Warrior	3.84 oz.	Aza-Direct	20.0 oz.
	MSR	2.0 pt.	Success	10.0 oz.
June 23	Warrior	3.84 oz.	Aza-Direct	20.0 oz.
	Lannate	3.0 pt.	Success	10.0 oz.
July 1	Warrior	3.84 oz.	Aza-Direct	20.0 oz.
	Lannate	3.0 pt.	Success	10.0 oz.
July 8	Warrior	3.84 oz.	Aza-Direct	20.0 oz.
	MSR	2.0 pt.	Success	10.0 oz.
July 19	Warrior	3.84 oz.	Aza-Direct	20.0 oz.
	Lannate	3.0 pt.	Success	10.0 oz.
July 29	Warrior	3.84 oz.	Aza-Direct	20.0 oz.
	Mustang	4.0 oz.	Success	10.0 oz.
	Lannate	3.0 pt.		

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

2003

Treatment	Medium	Jumbo	Colossal	Super-colossal	Total yield
	cwt/acre				
Untreated check	9.7	459.7	464.1	124.0	1057.5
Standard	9.8	451.0	489.6	140.9	1091.3
Alternative	10.9	446.1	484.2	145.2	1086.4
LSD (0.05)	ns	ns	ns	ns	ns

2004

Treatment	Medium	Jumbo	Colossal	Super-colossal	Total yield
	cwt/acre				
Untreated check	17.6	586.1	254.5	29.8	888.0
Standard	11.9	511.3	306.9	52.3	882.4
Alternative	14.8	409.3	377.4	126.9	928.4
LSD (0.05)	ns	ns	76.9	71.9	ns

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

2003

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

2004

Treatment	Medium	Jumbo	Colossal	Super-colossal	Total yield
	cwt/acre				
Untreated check	57.6	395.1	9.1	0	461.8
Standard	50.8	509.0	15.4	0	575.2
Alternative	52.1	445.6	36.9	0	534.6
LSD (0.05)	ns	ns	16.5	ns	ns

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

2003				
Treatments	Medium	Jumbo	Colossal	Total yield
	cwt/acre			
Untreated check	121.5	380.5	1.0	512.4
Standard	107.1	442.3	9.2	565.5
Alternative	94.0	486.1	19.1	606.9
LSD (0.05)	16.9	55.5	7.8	51.8

2004				
Treatments	Medium	Jumbo	Colossal	Total yield
	cwt/acre			
Untreated check	128.1	175.1	0.3	512.4
Standard	101.0	275.3	1.0	565.5
Alternative	82.2	305.9	10.7	606.9
LSD (0.05)	ns	ns	ns	51.8

Table 5. Average iris yellow spot virus injury for insecticide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	IYSV*
Untreated	1.5
Standard	1.7
Alternative	2.2
LSD (0.05)	0.4

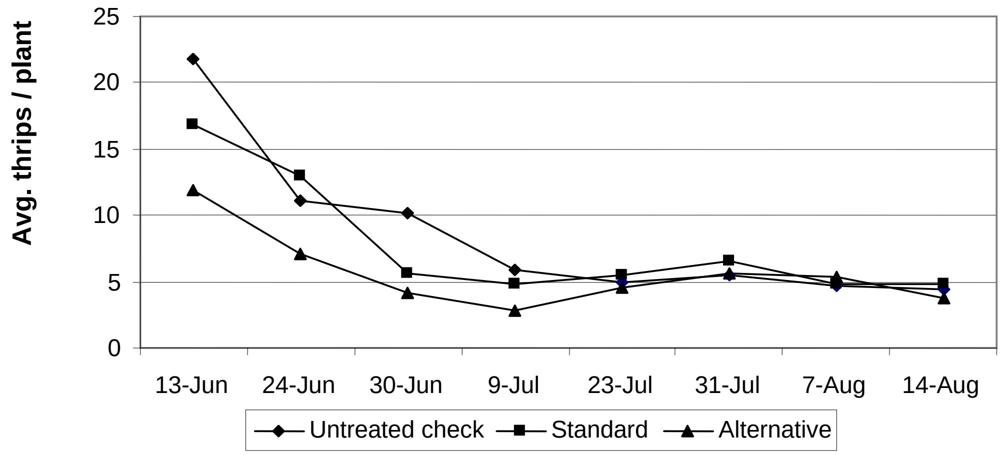
*Scale: 0 = dead, 5 = healthy, no lesions.

Table 6. Thrips injury on two stored red onion varieties, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Treatment	Thrips injury Redwing	Thrips injury Flamenco
	(0 = no injury, 10 = severe injury)	
Alternative	1	1.3
Standard	1.3	1.6
Untreated check	1.5	2.1
LSD (0.05)	0.3	ns

Varietal differences	
Redwing	1.27
Flamenco	1.68
LSD (0.05)	0.39

2003



2004

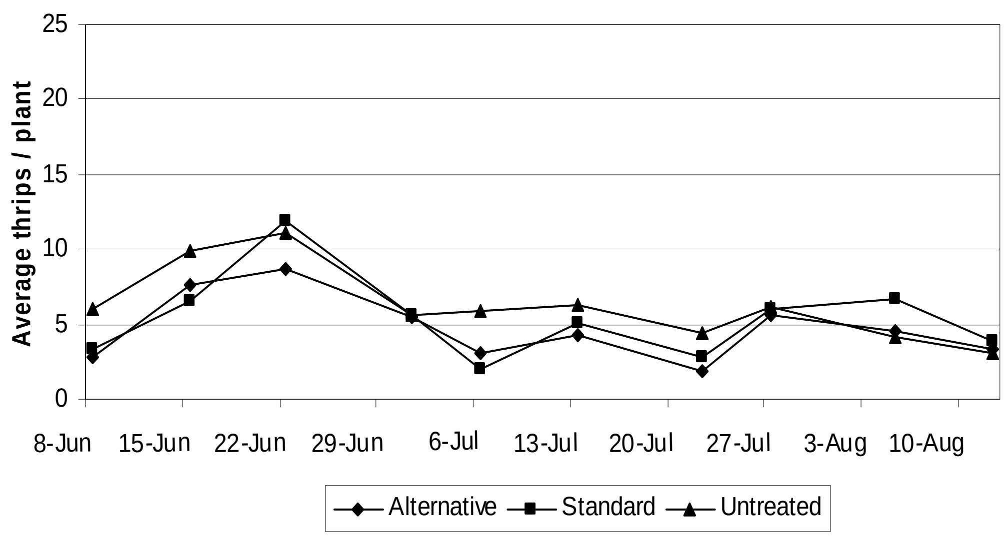
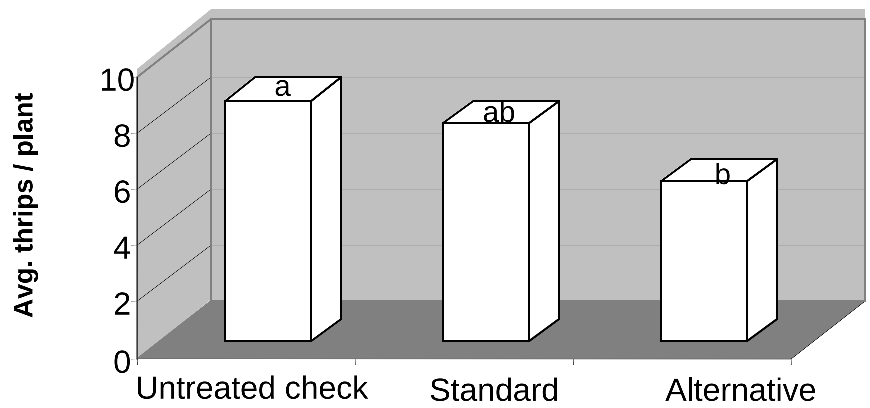


Figure 1. Thrips populations with different treatments in an alternative thrips control program, Malheur Experiment Station, Oregon State University, Ontario, OR.

2003



2004

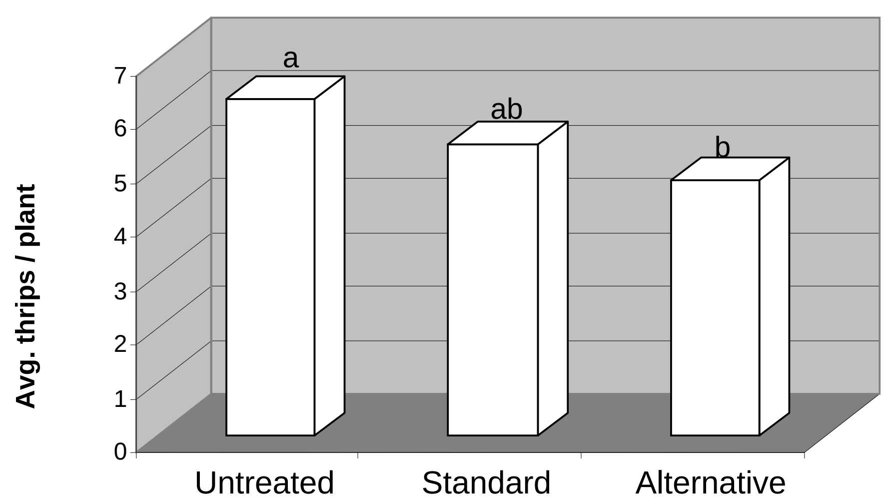


Figure 2. Average season-long thrips populations in an alternative thrips control program, Malheur Experiment Station, Oregon State University, Ontario, OR.

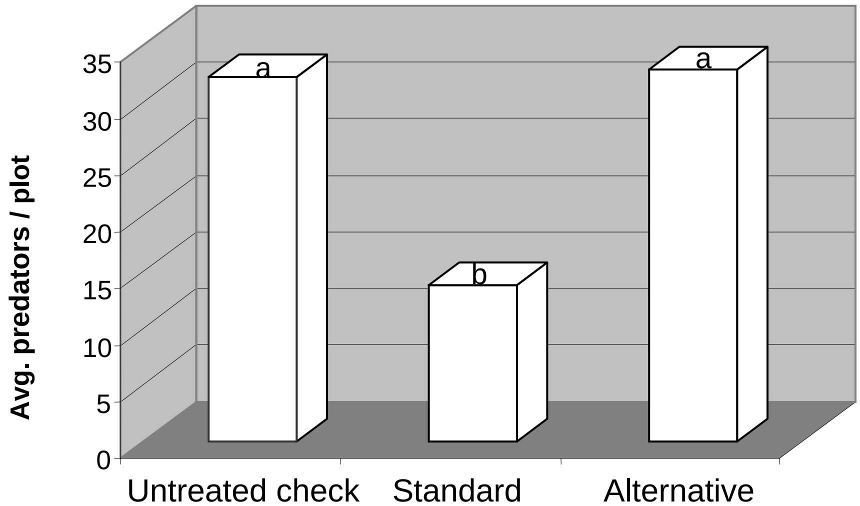


Figure 3. Predator populations in the alternative thrips trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

A ONE-YEAR STUDY ON THE EFFECTIVENESS OF OXAMYL (VYDATE L®) TO CONTROL THRIPS IN ONIONS WHEN INJECTED INTO A DRIP-IRRIGATION SYSTEM

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Introduction

Onion thrips and western flower thrips are the main insect pests on onions grown in the Treasure Valley of Idaho and eastern Oregon. In this region about 3,000 acres of onions are grown under drip irrigation. Because of the increased yield and quality of onions grown under drip irrigation, this management practice is increasing on lands that were formerly marginal for onion production. It is a common practice to inject the systemic insecticide oxamyl (Vydate L®) into the drip lines on a weekly or biweekly basis to control thrips. Most growers also apply two to six foliar insecticide applications in addition to the oxamyl applications. Growers using conventional furrow irrigation commonly use four to six foliar insecticide applications for thrips control. The drip irrigation growers feel there is an economic advantage to the additional oxamyl applications even though the additional cost is about $150/acre. This trial was designed to determine the effectiveness of oxamyl at two different application rates and in combination with two foliar insecticide programs.

Materials and Methods

The trial was conducted at the Malheur Experiment Station on an Owyhee silt loam soil previously planted to wheat. Onion (cv: ‘Vaquero’; Nunhems, Parma, ID) was planted on March 23 in 2 double rows on a 44-inch bed. The double rows were spaced 2 inches apart. The seeding rate was 150,000 seeds/acre. Lorsban 15G® was applied in a 6-inch band over each double row at a rate of 3.7oz/1,000 ft of row for maggot control. The drip tape was placed in the center of the bed between the double rows. The drip tape (T-tape, T-Systems International, Inc., San Diego, CA) had a flow rate of 0.22 gal/min/100 ft of tape. Irrigation water was applied when the soil water potential reached –20 kPA. Water potential was determined by granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200ss, Irrometer Co. Inc., Riverside, CA) installed at 8-inch depth in the center of the double row.

The experimental design was a randomized complete block design with four replications. The plot size was 8 double rows wide (37.5 ft) by 34 ft in length.

Oxamyl was injected into the main irrigation line by a positive displacement injector (Dosmatic Model A30, Dosmatic USA, Inc., Carollton, TX). Prior to injecting oxamyl, 95 percent sulfuric acid was diluted at a ratio of 1:6,248 acid to water to buffer the water in the soil solution to a pH of 5.0. The oxamyl was added to water buffered at the same ratio and injected immediately after the initial buffer treatment. The buffered water and buffered oxamyl treatments required 20 minutes each to inject into the treated plots. This process applied slightly more water to the treated plots compared to the untreated, but the additional water was minor compared to the overall applied water and probably did not have an overall impact on the final yield.

Each plot had four drip tapes supplying water to the eight double rows. Each plot was equipped with an on/off valve so that oxamyl could be applied to individual plots as needed. There were 6 treatments including an untreated check, a standard insecticide program, oxamyl at 1.0 qt/acre applied weekly, oxamyl at 2.0 qt/acre applied every other week, oxamyl at 1.0 qt/acre plus a standard insecticide program and oxamyl at 1.0 qt/acre plus the bio-insecticides azadirachtin (Aza-Direct®) and spinosad (Success®) (alternative program). Azadirachtin and spinosad have shown promise under conventional systems by suppressing thrips and allowing predatory insect populations to build to the point where they control thrips. Systemically applied through the drip system, oxamyl has the potential to enhance this program. The application dates of the treatments are shown in Tables 1 and 2.

Thrips counts were made weekly by counting the total number of thrips on 15 plants in each plot. Onions were harvested on September 9 and10 and graded on October 5. A visual evaluation for iris yellow spot virus was taken on August 19.

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

Results and Discussion

Figure 1 shows the weekly thrips populations found in the different treatments throughout the growing season. There was a tendency for the oxamyl plus alternative treatments to have lower thrips pressure than the other treatments. The season average thrips populations are shown in Table 3. The oxamyl at 1.0 qt every week plus the alternative bio-insecticides had significantly lower total thrips populations than the other treatments. There were no significant differences in thrips populations between the other treatments, including the untreated check.

Table 4 shows the breakdown in yield and quality between the different treatments. There was a significant increase in colossal-sized bulbs with the three foliar-applied insecticide treatments versus the untreated check or the oxamyl alone treatments.

Iris yellow spot virus (IYSV), which is thrips transmitted, appeared in the trial during August. A visual evaluation of the onions for IYSV showed significantly less infection in the oxamyl plus azadirachtin plus spinosad treatment compared to the oxamyl alone treatments or the untreated check (Table 5).

Conclusion

The oxamyl plus alternative insecticides (azadirachtin plus spinosad) treatment significantly controlled thrips better than any other treatment and had the highest yield of colossal, super-colossal, and total yield. All of the treatments with foliar insecticides gave significantly higher colossal yields compared to the oxamyl only and the untreated check. Oxamyl treatments applied as 1.0 qt/acre weekly or 2.0 qt/acre every other week were no better than the untreated check. The lack of thrips control by oxamyl may be due to the late initial application on June 3. This application was about 2 weeks later than growers would typically start. There was also the possibility that the oxamyl was not applied with enough irrigation water to allow movement to the onion roots during the early onion growth period when the root zone was small.

Table 1. Application dates for the different treatments in the drip-irrigation/oxamyl trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Date	Oxamyl 1.0 qt/wk	Oxamyl 2.0 qt every other week	Standard insecticide	Alternative insecticide
6/03	X	X		
6/04			X	X
6/11	X	X		
6/16	X		X	X
6/23			X	X
6/25	X			
7/02	X	X	X	X
7/08	X		X	X
7/19			X	
7/20	X	X		
7/29			X	X
8/06	X			

Table 2. Application dates for foliar insecticide applications for thrips control on drip-irrigated onions, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

	Product	Rate/acre	Product	Rate/acre
June 6	Warrior MSR	3.84 oz. 2.0 pt.	Aza-Direct Success	20.0 oz. 10.0 oz.
June 16	Warrior MSR	3.84 oz. 2.0 pt.	Aza-Direct Success	20.0 oz. 10.0 oz.
June 23	Warrior Lannate	3.84 oz. 3.0 pt.	Aza-Direct Success	20.0 oz. 10.0 oz.
July 1	Warrior Lannate	3.84 oz. 3.0 pt.	Aza-Direct Success	20.0 oz. 10.0 oz.
July 8	Warrior MSR	3.84 oz. 2.0 pt.	Aza-Direct Success	20.0 oz. 10.0 oz.
July 19	Warrior Lannate	3.84 oz. 3.0 pt.	Aza-Direct Success	20.0 oz. 10.0 oz.
July 29	Warrior Mustang Lannate	3.84 oz. 4.0 oz. 3.0 pt.	Aza-Direct Success	20.0 oz. 10.0 oz.

Table 3. Average thrips counts for the 2004 season, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Average thrips/plant
Untreated	47.9
oxamyl 2.0 qt - every other week	51.8
oxamyl 1.0 qt - every week	50.7
oxamyl 1.0 qt + alternative	36.2
oxamyl 1.0 qt + standard	49.6
Standard treatment	50.1
LSD (0.05)	9.6

Table 4. Total yield of oxamyl-treated onions grown under drip irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

	Onion Yield				
Treatment	Medium	Jumbo	Colossal	Super-colossal	Total yield
	----------cwt/acre----------				
Untreated	26.4	676.3	198.3	11.9	912.9
oxamyl 2.0 qt (every other week)	30.4	642.3	210.8	22.8	906.3
oxamyl 1.0 qt (every Week)	22.8	708.1	193.5	13.3	937.7
oxamyl 1.0 + Alternative	19.6	630.5	326.4	46.1	1022.6
oxamyl 1.0 + Standard	17.4	633.7	307.4	34.7	993.2
Standard only	21.3	655.6	310.9	28.0	1015.8
LSD (0.05)	ns	ns	91.3	ns	ns

Table 5. Iris yellow spot virus (IYSV) evaluation in oxamyl-treated onions grown under drip irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	IYSV rating 1 = no virus, 5 = severe virus
Untreated	3
oxamyl 2.0 qt (every other week)	3
oxamyl 1.0 qt (every Week)	3.3
oxamyl 1.0 + Alternative	1.8
oxamyl 1.0 + Standard	2.5
Standard only	2.5
LSD (0.05)	0.9

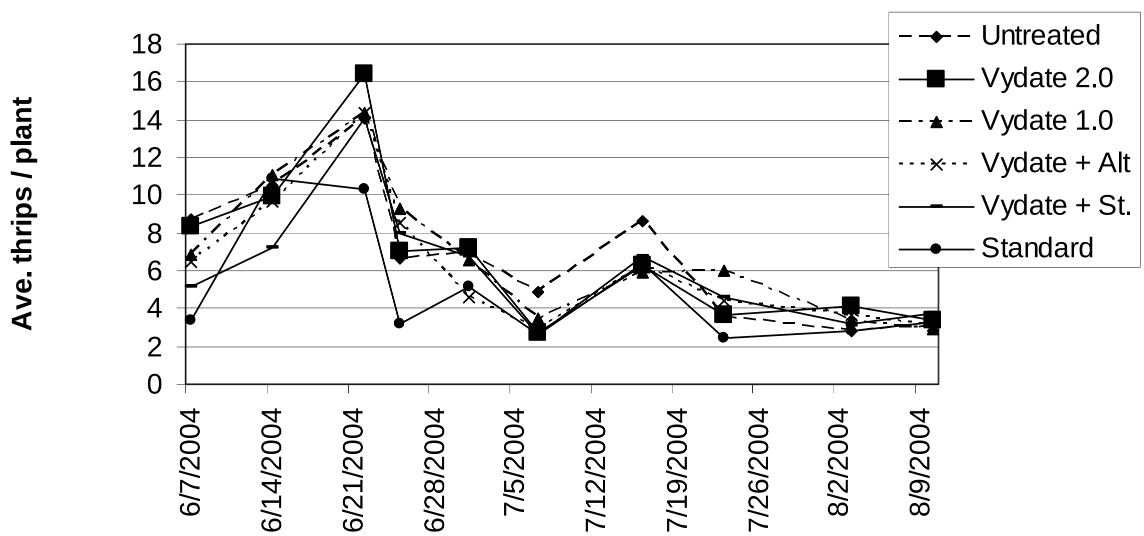

Figure 1. Weekly thrips populations, 2004 oxamyl/drip trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

GROWERS USE LESS NITROGEN FERTILIZER ON DRIP-IRRIGATED ONION THAN FURROW-IRRIGATED ONION

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Summary

Over previous years, research at the Malheur Experiment Station has shown that nitrogen (N) needs of drip-irrigated onion can be modest (Shock et al. 2004). In 2002, surveys of two growers' furrow-irrigated and drip-irrigated onion fields showed that N fertilizer use efficiency was substantially better in drip-irrigated fields than in furrow-irrigated fields (Shock and Klauzer 2003). In 2004 we repeated this survey with various growers' fields.

Introduction

Drip irrigation is generally used on fields with imperfect topography, lower soil fertility, and histories of lower productivity compared to the fields used for furrow irrigation. From 1992 to 1994 we demonstrated that drip irrigation is an effective irrigation practice compared to furrow and sprinkler irrigation for onion production on Treasure Valley soils that were difficult to irrigate (Feibert et al. 1995). While 320 lb N/acre is commonly used in furrow-irrigated onion production, drip-irrigated onion is not very responsive to N fertilizer (Shock et al. 2004). The lower response of drip-irrigated onion could be because less irrigation water is applied using drip. With less irrigation, water is less apt to leach away residual soil nitrate and N from mineralization, allowing these N sources to supply the crop much of its N needs. Here we report growers' 2004 nitrogen fertilization practices using drip- and furrow-irrigation systems and the corresponding crop yields.

Materials and Methods

Growers were asked to keep records of all fertilizer and water supplied to their onion fields. Yield was recorded for each field. The soil water potential was monitored in selected fields. The bulb yield was recorded. This report covers the yield, N applied, and yield per unit of applied N fertilizer for onions grown using drip and furrow irrigation. Some of the drip-irrigated fields were of poorer soil quality than the corresponding furrow-irrigated fields.

Although root tissue testing for nitrate is a proven method to assure adequate supplies of N for onion, to improve yields, and save on N fertilizer costs, none of the growers surveyed conducted root tissue testing.

Results and Discussion

For the growers and fields surveyed in 2004, growers applied on average 279 lb N/acre when growing onions with furrow irrigation, while only 173 lb N/acre was applied with drip irrigation (Table 1). These N rates include all N applied during the fall prior to the crop year, spring preplant fertilizer, sidedressed N, and N applied by fertigation in the irrigation water.

Drip irrigation out-yielded furrow irrigation by an average of 68 cwt/acre for 4 growers and furrow irrigation out-yielded drip by 300 cwt/acre for 1 grower (Table 1). The low yielding drip-irrigated onion was from a very unfavorable field. The 2004 Treasure Valley growing season was favorable for high onion yields and excellent onion quality. During previous years, with more heat and water stress potential, larger yield differences were observed in favor of drip irrigation.

As a consequence of lower N fertilizer rates used for drip-irrigated onions than for furrow-irrigated onion, more onions were produced for each pound of applied N using drip (Table 1). The surveyed growers might have economized further on N fertilizer costs through root tissue testing for nitrate. Thorough nutrient management for onion has been described by Sullivan et al. (2001) and the methods they discuss are underutilized.

Growers used less N fertilizer under drip irrigation and yields were on average similar to furrow irrigation even though the soils in a few cases had less favorable physical and chemical properties. Under furrow irrigation, much more water is applied at each irrigation. The potential for deep leaching of nitrate and groundwater contamination is substantial with furrow irrigation. With drip irrigation it is easier to maintain uniform soil moisture, even on difficult sites. Since each water application with a drip system can be carefully managed to just replace water used by the crop, nitrate leaching can be greatly reduced with drip irrigation, and this results in better N fertilizer use at a commercial scale.

Drip irrigation may provide an important option for growers who wish to rotate onion onto soils not usually used for the crop. These fields may not be as highly infested with pathogens from short rotations of cash crops.

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Table 1. Comparison of nitrogen (N) fertilizer rates, onion yield, and bulb yield per pound of applied N in furrow-irrigated and drip-irrigated onion, Treasure Valley of Oregon and Idaho, 2004.

	Grower					Average
	1	2	3	4	5	
Furrow irrigation						
N rate, lb/acre	250	320	275	250	300	279
Yield, cwt/acre	810	800	855	750	850	813*
Ratio, cwt/lb N	3.24	2.5	3.11	3	2.83	2.94
Drip irrigation						
N rate, lb/acre	140	175	150	230	172	173
Yield, cwt/acre	860	850	930	850	550†	808*
Ratio, cwt/lb N	6.14	4.86	6.2	3.7	3.2	4.82

*Often drip-irrigated onion is grown on soil that is less favorable than furrow-irrigated onion.

†Extremely unfavorable soil.

PERFORMANCE OF HYBRID POPLAR CLONES ON AN ALKALINE SOIL

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Introduction

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

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

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

Materials and Methods

2003 Procedures

The trial was conducted on Nyssa silt loam with 1.3 percent organic matter and a pH ranging from 7.7 at the field top to 8.4 at the field bottom. The field had been planted to wheat in the fall of 2002. On March 28, 2003, the wheat was sprayed with Roundup® (Glyphosate) at 1.5 lb ai/acre. Based on a soil analysis, on April 9, 2003, 20 lb magnesium (Mg), 40 lb potassium (K), 1 lb boron (B), and 1 lb copper (Cu) per acre were broadcast. The field was again sprayed with Roundup at 1.5 lb ai/acre on April 9. On April 10, 9-inch poplar sticks of 24 clones (Table 1) were planted in a randomized complete block design with 5 replicates. Three of the clones were designated Malheur 1, 2, and 3 corresponding to three selections of eastern cottonwood (*Populus deltoides*) found growing in Malheur County. Tree rows were spaced 5 ft apart and trees were spaced 5 ft apart within the rows. Each plot consisted of four trees two rows wide and two trees long. Goal® herbicide (Oxyfluorfen) at 2 lb ai/acre was applied on April 11. The field was irrigated with 0.6 inch of water on April 11.

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

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

2004 Procedures

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

On August 10, leaf chlorophyll content was measured on two leaves per tree using a Minolta SPAD 502 DL meter (Konica Minolta Photo Imaging U.S.A., Inc., Mahwah, NJ). On August 20, trees in all plots were evaluated subjectively for visual symptoms of leaf chlorosis. On September 10 the trees in all plots were evaluated subjectively for stem defects. The heights and diameter at breast height (DBH, 4.5 ft from ground) of all trees in each plot were measured in October 2003 and 2004. Stem volumes (cubic feet, excluding bark and including stump and top) were calculated for each tree using an equation (stem volume = $10^{(-2.945047+1.803973*LOG10(DBH)+1.238853*LOG10(Height))}$) developed for poplars that uses tree height and DBH (Browne 1962). Clonal differences in height, DBH, and wood volume were compared using ANOVA and least significant differences at the 5 percent probability level, LSD (0.05). The LSD (0.05) values at the bottom of Table 2 should be considered when comparisons are made between clones for significant differences in performance characteristics. Differences between clones equal to or greater than the LSD (0.05) value for a characteristic should exist before any clone is considered different from any other clone in that characteristic. To evaluate the sensitivity of the clones to soil pH, a regression analysis of leaf chlorophyll content against soil pH was run for each clone separately. If the regression analysis had a probability level of 5 percent or less, the clone was considered to be sensitive to soil pH.

Results and Discussion

Starting around mid-July 2003 and 2004, the soil water potential failed to remain above the target of -25 kPa (Fig. 1). A total of 22 and 44 inches of water plus precipitation were applied during the season to the whole field in 2003 and 2004, respectively (Fig. 2). Based on our previous work (Shock et al. 2002), greater tree growth and wood volume would have been expected if the intended soil water potential could have been maintained, which would have required a greater amount of water to be applied. However, water infiltration in this field was restricted; we observed runoff out of the bottom of the field.

Chlorotic leaves were observed on trees in replicates 2, 3, and 4 of the trial. The soil pH was 7.7, 8.2, 8.4, and 8.4 for replicates 1 to 4, respectively. Relative leaf chlorophyll content rankings ranged among clones from 25.8 to 49.3 percent (Table 2). The regression analysis of soil pH and leaf chlorophyll content showed some clones to be insensitive to soil pH in terms of leaf chlorophyll content (Table 2). The leaf chlorophyll content of the sensitive clones decreased with increasing soil pH. The leaf chlorophyll content of the clones insensitive to soil pH (12 clones) averaged 42.4 percent. The leaf chlorophyll content of the clones sensitive to soil pH (12 clones) averaged 31.8 percent. There was a linear relationship ($R^2 = 0.62$, $P = 0.001$) between leaf chlorophyll content and the visual rating of leaf chlorosis (Fig. 3). The trees insensitive to soil pH averaged a subjective visual rating of leaf chlorosis of 0.52 (0 = no visual symptoms of chlorosis, 5 = very chlorotic). The trees sensitive to soil pH averaged a visual rating of leaf chlorosis of 2.15. The three *P. deltoides* selections from Malheur County had among the darkest green leaves, and leaf sizes were smaller. For the clones sensitive to soil pH, tree growth decreased with increasing severity of leaf chlorosis and with decreasing leaf chlorophyll content (Figs. 4 and 5). For the clones insensitive to soil pH, tree growth was not related to leaf chlorosis or leaf chlorophyll content.

Subjective rating of stem defects (0 = no defects, 2 = more than half of the trees have either split or crooked tops) ranged from 0 defects for clone 57-276 to 1.75 for clone 49-177 (Table 1).

Tree height in October 2004 ranged from 13 ft for 50-184 to 22.6 ft for 59-289 (Table 2). Diameter at breast height ranged from 1.45 inches for 311-93 to 2.41 inches for 184-401. Stem volume ranged from 119.3 inch^3 for 50-184 to 437 inch^3 for 59-289. Clones 59-289, Malheur 3, 184-401, and 50-197 were among those with the greatest stem volume. Stem volume growth in 2004 ranged from 113.3 inch^3 for 50-184 to 414.2 inch^3 for 59-289. Clones 59-289, Malheur 3, 184-401, and 50-197 were among those with the greatest stem volume growth in 2004.

Considering all measured characteristics, clones 59-289 and Malheur 3 had among the best performance over the 2 years of the trial. These two clones had high growth, high leaf chlorophyll content, insensitivity to soil pH, and low incidence of stem defects. Clone 59-289 was taller than OP-367. Compared to OP-367, clones 59-289 and Malheur 3 had greater stem volume, but were similar in leaf chlorophyll content, insensitivity to soil pH, and incidence of stem defects. The choice of clones for commercial production needs to be made on the basis of wood productivity through an entire growth cycle and ultimately on wood quality, parameters that are currently unavailable for 59-289 and Malheur 3.

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

Nutrient	Sufficiency range*	July 11, 2003 analysis	July 8, 2004 analysis
N (%)	3 - 3.5	4.02	3.73
P (%)	0.3 - 0.4	0.45	0.41
K (%)	1.7 - 2.1	5.88	2.52
S (%)	0.3 - 0.4	0.22, deficient	0.64
Ca (%)	0.8 - 1.2	0.9	1.55
Mg (%)	0.15 - 0.25	0.29	0.57
Zn (ppm)	15 - 25	36	29
Mn (ppm)	70 - 110	81	115
Cu (ppm)	3 - 5	12	16
Fe (ppm)	65 - 95	256	205
B (ppm)	35 - 45	17, deficient	25, deficient

* analyses by Western Labs, Parma, ID.

Figure 1. Average soil water potential at 8-inch depth during 2003 and 2004 for poplar clones irrigated with a drip-irrigation system with two emitters per tree, Malheur

Experiment Station, Oregon State University, Ontario, OR.

Figure 2. Cumulative water applied to poplar clones in 2003 and 2004. Trees were irrigated with a drip-irrigation system with two emitters per tree, Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 3. Relationship between relative leaf chlorophyll content measured with a Minolta SPAD meter and subjective rating of leaf chlorosis (0 = no chlorosis symptoms, 5 = severe chlorosis symptoms), Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 2. Performance of hybrid poplar clones planted on April 10, 2003 at the Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

			November 2004 measurem.			2004 growth increment			Leaf chlorophyll content	Leaf chlorosis symptoms
No.	Clone	Cross	Height	DBH	Wood volume	Height	DBH	Wood volume		
			feet	inch	$inch^3$/tree	feet	inch	$inch^3$/tree	0 - 100	0 - 5*
1	15-29	*P. trichocarpa X P. deltoides*	18.89	1.95	283.6	7.98	1.23	253.0	35.70	1.50
2	50-184	*P. trichocarpa X P. deltoides*	13.02	1.63	119.3	5.66	1.19	113.3	31.10	2.50
3	50-197	*P. trichocarpa X P. deltoides*	20.20	2.19	348.5	10.07	1.45	333.2	30.30	3.00
4	52-225	*P. trichocarpa X P. deltoides*	18.77	1.93	252.1	9.90	1.35	240.5	26.60	3.00
5	55-260	*P. trichocarpa X P. deltoides*	16.62	1.80	203.6	7.24	1.25	191.7	25.80	2.75
6	56-273	*P. trichocarpa X P. deltoides*	19.81	2.11	318.6	10.10	1.48	303.1	40.80	1.00
7	57-276	*P. trichocarpa X P. deltoides*	16.85	1.90	214.3	6.66	1.22	195.4	36.30	1.75
8	58-280	*P. trichocarpa X P. deltoides*	17.76	2.00	252.5	9.01	1.40	240.2	44.40	0.75

9	59-289	*P. trichocarpa X P. deltoides*	22.56	2.30	437.0	10.07	1.35	414.2	42.00	0.50
10	184-401	*P. trichocarpa X P. deltoides*	20.39	2.41	407.1	7.24	1.26	385.5	34.00	0.50
11	184-411	*P. trichocarpa X P. deltoides*	19.61	2.05	312.5	10.02	1.38	300.4	32.40	1.50
12	195-529	*P. trichocarpa X P. deltoides*	17.68	1.96	246.3	7.25	1.29	227.3	32.20	1.50
13	309-74	*P. trichocarpa X P. nigra*	19.89	2.02	302.6	8.78	1.28	282.4	26.30	2.75
14	311-93	*P. trichocarpa X P. nigra*	16.40	1.45	141.9	7.66	1.00	133.9	30.20	3.25
15	NM-6	*P. trichocarpa X P. maximowiczii*	18.60	1.78	214.0	8.24	1.14	196.5	43.50	1.50
16	DTAC-7	*P. trichocarpa X P. deltoides*	15.18	1.66	171.0	7.25	1.20	162.5	34.00	2.00
17	OP-367	*P. deltoides X P. nigra*	18.10	2.10	284.9	8.14	1.46	269.1	40.60	0.00
18	PC1	*P. deltoides X P. nigra*	20.17	2.09	310.3	10.99	1.56	300.0	45.80	0.00
19	PC2	*P. trichocarpa X P. deltoides*	18.68	1.82	221.0	9.47	1.23	208.7	45.30	0.25
20	49-177	*P. trichocarpa X P. deltoides*	18.75	1.82	237.9	9.46	1.24	228.7	33.50	1.50
21	Malheur 1	*P. deltoides,* Malheur County, OR	19.79	1.53	186.4	10.16	1.01	176.7	49.30	0.00
22	Malheur 2	*P. deltoides*, Malheur County, OR	18.18	1.59	177.8	8.14	0.94	167.7	46.70	0.00
23	Malheur 3	*P. deltoides*, Malheur County, OR	19.92	2.37	407.9	9.64	1.59	396.1	42.20	0.00
24	DN-34	*P. deltoides X P. nigra*	20.25	1.87	259.3	12.24	1.36	250.2	43.80	0.50
LSD (0.05)			2.17	0.32	102.9	1.98	0.24	98.2	8.80	1.61

*Subjective evaluation of leaf chlorosis on a scale of 0-5: 0 = no symptoms, 5 = very chlorotic.
†Subjective evaluation of trunk defects on a scale of 0-2: 0 = all trees have straight stems and single tops, 1 = less than half of trees have either split or crooked stems, 2 = more than half of the trees have either split or crooked stems.

Figure 4. Relationship between leaf chlorosis symptoms (0 = no symptoms, 5 = severe chlorosis symptoms) and stem volume in September 2004 for hybrid poplar clones sensitive to soil pH, Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 5. Relationship between relative leaf chlorophyll content and stem volume in September 2004 for hybrid poplar clones sensitive to soil pH, Malheur Experiment Station, Oregon State University, Ontario, OR.

MICRO-IRRIGATION ALTERNATIVES FOR HYBRID POPLAR PRODUCTION 2004 TRIAL

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Summary

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

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, Oregon have made experimental plantings of hybrid poplars for saw logs and peeler logs. Clone trials in Malheur County during 1996 demonstrated that the clone OP-367 (hybrid of Populus deltoides x P. nigra) grew well on alkaline soils. Over the last 8 years OP-367 has continued to grow well on alkaline soils. Some other clones have higher productivity on soils with nearly neutral pH.

Hybrid poplars are known to have high growth rates (Larcher 1969) and transpiration rates (Zelawski 1973), suggesting that irrigation management is a critical cultural practice. Research at the Malheur Experiment Station during 1997-1999 determined optimum microsprinkler irrigation criteria and water application rates for the first 3 years (Shock et al. 2002). These results showed that tree growth was maximized by irrigating at -25 kPa, but 38 irrigations were required for 3-year-old trees, and more were anticipated for larger trees. Based on simplicity of operations, we decided to use an irrigation criterion of -50 kPa for the wettest treatments starting in 1998. In 2000 we noticed that the rate of increase in annual tree growth started to decline in the wettest treatment. One of the causes probably was the use of an irrigation criterion of -50 kPa. Starting in 2003 the irrigation criterion was changed to -25 kPa for the wettest treatment. The objectives of this study were to evaluate poplar water requirements and to compare microsprinkler irrigation to drip irrigation.

Materials and Methods

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

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

Procedures common to all treatments. In March 2000 the field was divided into 20 plots, each of which was 6 tree rows wide and 7 trees long. The plots were allocated to five treatments arranged in a randomized complete block design and replicated four times (Table 1). The microsprinkler-irrigation treatments used the existing irrigation system. For the drip-irrigation treatments, either one or two drip tapes (Nelson Pathfinder, Nelson Irrigation Corp., Walla Walla, WA) were laid along the tree row in early May 2000. The plots with 2 drip tapes per tree row had the drip tapes spread 2 ft apart, centered on the tree row. The drip tape had emitters spaced 12 inches apart and a flow rate of 0.22 gal/min/100 ft at 8 psi. Each plot had a pressure regulator (set to 25 psi for the microsprinkler plots and 8 psi for the drip plots) and a 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 6 granular matrix sensors (GMS; Watermark Soil Moisture Sensors model 200SS; Irrometer Co. Inc., Riverside, CA); 2 at 8-inch depth, 2 at 20-inch depth, and 2 at 32-inch depth. The GMS were installed along the middle row in each plot and between the riser and the third tree. The GMS were previously calibrated (Shock et al. 1998) and were read at 8:00 a.m. daily starting on May 2 with a 30 KTCD-NL meter (Irrometer Co. Inc., Riverside, CA). The daily GMS readings were averaged separately at each depth within each plot and over all plots in a treatment. Irrigation treatments were started on May 2.

The five irrigation treatments consisted of three water application rates for the microsprinkler-irrigated plots and two water application rates for the drip-irrigated plots (Table 2). From 2000 through 2002, all plots in the 3 microsprinkler-irrigated treatments were irrigated whenever the SWP at 8-inch depth, averaged over all plots in treatment 1, reached -50 kPa. The plots in each drip-irrigated treatment were irrigated whenever the SWP at 8-inch depth, averaged over all plots in 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 (r2) 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.

The heights and diameter at breast height (DBH, 4.5 ft from ground) of the central three trees in the two middle rows in each plot were measured monthly from May through September. Tree heights were measured with a clinometer (model PM-5, Suunto, Espoo, Finland) and DBH was measured with a diameter tape. Stem volumes (excluding bark and including stump and top) were calculated for each of the central six trees in each plot using an equation developed for poplars that uses tree height and DBH (Browne 1962). Growth increments for height, DBH, and stem volume were calculated as the difference in the respective parameter between October of the current year and October of the previous year. Curves of current annual increment (CAI) and mean annual increment (MAI) over the 8 years for the treatment 1 microsprinkler-irrigated trees and for the 2 drip tape configurations were used to assess the growth stage of the plantation. The CAI is the current increment in stem volume and the MAI is the CAI divided by the tree age.

2000 Procedures. The side branches on the bottom 6 ft of the tree trunk had been pruned from all trees in February, 1999. In March of 2000, another 3 ft of trunk were pruned, resulting in 9 ft of pruned trunk. The pruned branches were flailed on the ground and the ground between the tree rows was lightly disked on April 12. On April 24, Prowl® at 3.3 lb ai/acre was broadcast for weed control. The microsprinkler-irrigated plots received 0.7 inch of water to incorporate the

Prowl. To control the alfalfa and weeds remaining from the previous years' groundcover trial in the top half of the field, Stinger ® at 0.19 lb ai/acre was broadcast between the tree rows on May 19, and Poast® at 0.23 lb ai/acre was broadcast between the tree rows on June 1. On June 14, Stinger at 0.19 lb ai/acre and Roundup® at 3 lb ai/acre were broadcast between the tree rows on the whole field.

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

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

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

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

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

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

Starting in 2003 the irrigation criterion was changed to -25 kPa and the water applied at each irrigation was reduced accordingly (Table 2). All plots in the three microsprinkler-irrigated treatments were irrigated whenever the SWP at 8-inch depth, averaged over all plots in treatment 1, reached -25 kPa. The plots in each drip-irrigated treatment were irrigated whenever the SWP at 8-inch depth, averaged over all plots in the respective treatment, reached -25 kPa. Irrigation treatments were terminated on September 30.

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

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

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

Results and Discussion

In 2004, the microsprinkler-irrigated treatment with 1 inch of water applied at each irrigation received 51.7 acre-inch/acre of water in 43 irrigations (Table 1). The drip treatment with 1 inch of water applied with 2 tapes received 56 acre-inch/acre applied in 38 irrigations. The drip treatment with 0.5 inch of water applied with 1 tape received 34 acre-inch/acre in 44 irrigations. The large discrepancies between the number of irrigations applied and the actual amount of water applied can be explained by inefficiencies in the irrigation system, such as leaks caused by rodent damage. The tree squirrel population in an adjacent walnut orchard was inadvertently allowed to increase, resulting in extensive damage to the drip and microsprinkler irrigation systems in the spring of 2004. Repairs to the irrigation system and squirrel control measures brought the situation under control by mid-June.

In November 2004 (eighth year), trees in the wettest sprinkler-irrigated treatment and the 2-drip-tape configuration had the highest stem volume (Table 2). In November 2004, trees in the wettest sprinkler-irrigated treatment averaged 67 ft in height, 9 inch in DBH, and 2,459 ft3/acre in stem volume (Table 2). In November 2004, trees in the drip-irrigated treatment with 2 drip tapes per tree row averaged 70 ft in height, 9.6 inch in DBH, and 2,653 ft3/acre in stem volume. Trees in the wettest sprinkler-irrigated treatment and the 2 drip-tape configuration had among the highest accumulated tree growth from 2000 through 2004.

Comparing all treatments, drip irrigation with two tapes per tree row or the wettest sprinkler-irrigated treatment (water application rate of 1 inch) resulted in among the highest stem volume growth in 2004, although the differences in tree growth during 2004 were not statistically significant (Table 2).

Although tree growth increased with increasing applied water up to the highest amount tested, tree growth was not maximized in this study (Fig. 1). There were similar linear relationships, with similar slopes, between total water applied and stem volume growth for the drip and microsprinkler systems in 2004 (Y = -245.37 + 16.56X, R2 = 0.91, P = 0.05 for the drip and Y = -393.37 + 20.14X, R2 = 0.91, P = 0.05 for the sprinkler).

For the period of 2000 through 2004, there were distinctively different linear relationships, with similar slopes, between total water applied and the accumulated stem volume growth for the drip and microsprinkler systems (Fig. 2). The greater stem volume growth for the drip system reflected the higher water use efficiency of the drip system.

The soil water potential at 8-inch depth was maintained above the criterion of -25 kPa, except for brief periods during the season for microsprinkler irrigation with 1 inch of water applied and for drip irrigation with 2 tapes (Fig. 3). The soil water potential at 8-inch depth was reduced, as expected, with the reductions in the water application rate in the sprinkler treatments (Fig. 3, Table 3). During irrigations the soil water potential at 8-inch depth in the drip treatments was greater than in the sprinkler treatments, as expected, since the wetted area was smaller with drip irrigation (Fig. 3). It was difficult to maintain the irrigation criterion with the one drip tape configuration because of the smaller amount of water applied at each irrigation. With 1 drip tape, it takes 33 hours to apply 0.5 inch of water at each irrigation and usually about 30 hours later (the second morning after) the soil water potential would be equal to or considerably drier than -25 kPa.

The rate of increase in annual stem volume growth increased (growth approximately doubled every year) up to 2001, when the stem volume growth for the microsprinkler-irrigated trees started to decline (Table 4, Fig. 4). In 2002 the stem volume growth for the drip-irrigated trees started to decline. The decline in annual growth was not expected until later, when the trees approach harvest size. The reduction of the soil water potential from -25 to -50 kPa in 2000 might be associated with the decline in annual stem volume growth. Tree growth was substantially greater in 2003 and was approximately double the growth in 2002; this could have been due to the change to a wetter irrigation threshold from -50 to -25 kPa. In 2004, tree growth was less than in 2003 for the microsprinkler-irrigated and drip-irrigated trees for unexplained reasons. There were fewer growing degree days (50-86°F) from April through October in 2004 than in 2003 (Table 4).

Both the current annual increment (CAI) and the mean annual increment (MAI) continue to increase over time for the trees in treatment 1 (microsprinkler) and treatment 4 (drip, 2 tapes) (Fig. 4). Typically, both the CAI and MAI initially increase, reach a culmination point and then decline. The CAI will culminate before the MAI. The intersection of the two curves is termed the economic rotation and indicates the harvest stage of the plantation.

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Table 1. Irrigation rates, amounts, and water use efficiency for hybrid poplar submitted to five irrigation regimes in 2004, Malheur Experiment Station, Oregon State University, Ontario, OR.
*Includes 2.39 inches of precipitation from May through September.
†Soil water potential at 8-inch depth.

Table 2. Height, diameter at breast height (DBH), and stem volume in early November 2004, and 2004 growth in height, DBH, and stem volume for hybrid poplar submitted to five irrigation treatments, Malheur Experiment Station, Oregon State University, Ontario, OR.

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

	Average soil water potential		
Treatment	1st ft	2nd ft	3rd ft
	------------------- kPa --------------------		
1	22.2	21.6	19.1
2	32.9	33.1	30.4

3	99	58.9	72.4
4	20.2	22	22.8
5	30	16.7	20.6
LSD (0.05)	35.0*	13.0	6.5

*significant at P = 0.10.

Table 4. Annual stem volume growth, seasonal average soil water potential at 8-inch depth, and growing degree days for the drip and microsprinkler treatments receiving the most water, Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 1. Response of stem volume growth to water applied in 2004 for the drip and microsprinkler systems combined, Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 2. Response of stem volume growth to water applied from March 2000 through November 2004 for the drip and microsprinkler systems. Malheur Experiment Station, Oregon State University, Ontario, OR.

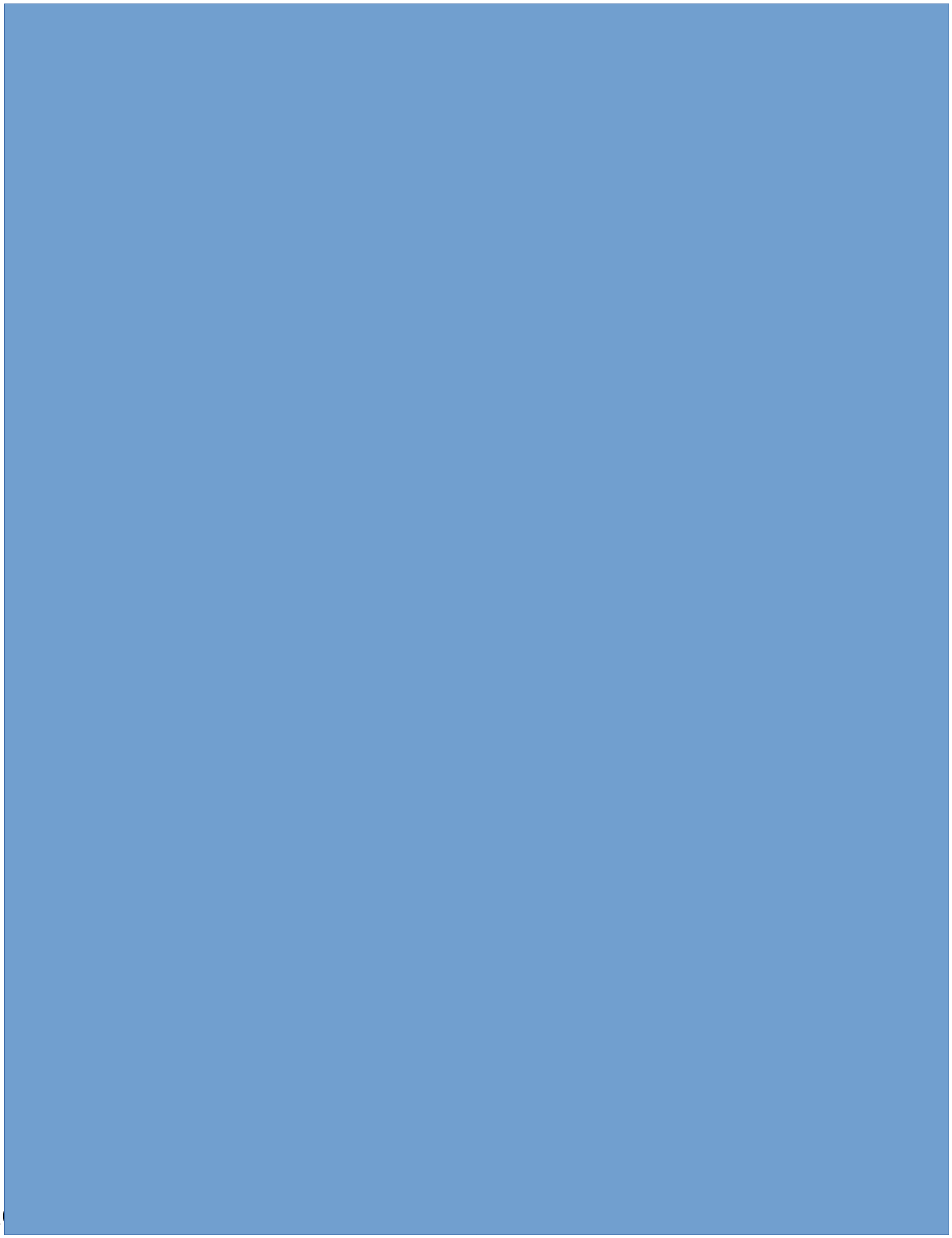

Figure 3. Soil water potential at three depths using granular matrix sensors in a poplar stand submitted to five irrigation regimes, Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 4. Current annual increment (CAI, annual stem volume growth) and mean annual increment (MAI, mean annual stem volume growth) starting at planting in 1997 through the eighth year for hybrid poplar irrigated with two drip tapes per tree row and with microsprinklers. Data are from plots receiving the highest irrigation rates, Malheur Experiment Station, Oregon State University, Ontario, OR.

EFFECT OF PRUNING SEVERITY ON THE ANNUAL GROWTH OF HYBRID POPLAR

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Summary

Hybrid poplar (clone OP-367) planted at 14-ft by 14-ft spacing was submitted to 5 pruning treatments. Pruning treatments consist of the rate at which the side branches are removed from the tree to achieve an 18-ft branch-free stem. Starting with a 6-ft (from ground) pruned trunk, 3-year-old trees are pruned to 18 ft in either 3, 4, or 5 years. Starting in March 2000, the side branches on the trunk were pruned to a height of 6, 9, or 12 ft. In subsequent years, the trees were pruned in 3-ft increments annually. A check treatment where trees were pruned only to 6 ft was included. In 2004 the percentage of the total tree height that was pruned ranged from 12 percent for the check treatment to 35 percent. Stem volume growth in 2004 and over the previous 5 seasons was not affected by pruning up to 23 percent of the total tree height.

Introduction

With reductions in timber supplies from Pacific Northwest public lands, sawmills and timber products companies are searching for alternatives. Hybrid poplar wood has proven to have desirable characteristics for many timber products. Growers in Malheur County, Oregon have made experimental plantings of hybrid poplar and demonstrated that the clone OP-367 (hybrid of *Populus deltoides x P. nigra*) performs well on alkaline soils for at least 7 years of growth. Research at the Malheur Experiment Station during 1997-1999 determined optimum irrigation criteria and water application rates for the first 3 years (Shock et al. 2002).

Pruning the side branches of trees allows the early formation of clear, knot-free wood in the trunk and increases the trees' value as saw logs and peeler logs. The amount of live crown removed might have an effect on tree growth. More severe pruning might improve the efficiency of the pruning operation (fewer pruning operations to reach the final pruning height), but could reduce growth excessively. The timing of pruning could also affect the amount of epicormic sprouting (sprouts forming on pruned stem) during the season, wound healing, and insect damage at wound sites. The objective of this study was to evaluate the effect of pruning severity and timing on tree growth and health.

Materials And Methods

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

In March 2000, the field was divided into 20 plots that were 6 rows wide and 7 trees long. The plots were allocated to five irrigation treatments that consisted of microsprinkler irrigation with three irrigation intensities and drip irrigation. The microsprinkler-irrigated plots used the existing irrigation system. For the drip-irrigated plots, either one or two drip tapes (Nelson Pathfinder, Nelson Irrigation Corp., Walla Walla, WA) were laid along the tree row in early May 2000. The management of the irrigation trial is discussed in an accompanying article (see “Mircro-irrigation Alternatives for Hybrid Poplar Production, 2004 Trial” in this report).

For the pruning study, only plots in the two wetter microsprinkler-irrigated treatments and the drip-irrigated treatments were used. The trees in the two wetter microsprinkler-irrigated treatments and the drip-irrigated treatments averaged 26 ft in height and 4.2 inches diameter at breast height (DBH) in March 2000. The middle 2 rows in each irrigation plot were assigned to pruning treatment 3 (Table 1). The remaining 2 pairs of border rows in each plot were randomly assigned to pruning treatments 2, 4, and 5. The pruning treatments were replicated eight times. The trees in treatments 2, 3, and 4 were pruned on March 27, 2000; March 14, 2001; March 12, 2002; March 12, 2003; and March 19, 2004. Trees in treatment 5 were pruned on May 16, 2000; May 21, 2001; May 15, 2002; and May 14, 2003. Trees were pruned by cutting all the side branches up to the specified height on the trunk, measured from ground level. The side branches were cut using loppers and pole saws. An additional 4 plots, in which the trees would remain pruned only to 6 ft, were selected for a check treatment (treatment 1).

The five central trees in the middle two rows and the five central trees in each inside row of each border pair in each plot were measured monthly for DBH and height. Trunk volumes were calculated for each of the measured trees in each plot using an equation developed for poplars that uses tree height and DBH (Browne 1962). Growth increments for height, DBH, and stem volume for 2004 were calculated as the difference in the respective parameter between October 2003 and October 2004. Growth increments for the five seasons (2000-2004) were calculated as the difference in the respective parameter between October 1999 and October 2004. Regression analyses were run for the percent of total tree height that was pruned trunk against tree growth. The maximum percent of total trunk height pruned that would not reduce tree growth was calculated by the first derivative (maximum = -b/2c) of the regression equation $Y = a + b \bullet X + c \bullet X^2$, where Y is the trunk volume increment and X is the percent of the total height pruned.

Results and Discussion

In 2004, the trees in the least intensive pruning treatment (treatment 2) were pruned to 18-ft height, completing the pruning treatments. In October 2004 the trees in the least severe pruning treatment (treatment 2) averaged 65.2 ft in height and 9.3 inches DBH. In 2003 the percentage of the total tree height that was pruned ranged from 12 percent for the check treatment to 35 percent for treatment 5 (Table 1). The differences in the percentage of the total tree height that was pruned trunk between treatments 2, 3, 4, and 5 was not significant in 2004, as all trees in these treatments were branch-free to 18 ft.

Tree growth increased, reached a maximum, and then decreased with increasing pruning severity, both in 2004 and over the 4 years (Figs. 1 and 2). The response of tree growth to pruning suggests that pruning up to a certain severity is beneficial for tree growth. Pruning removes branches from the lower canopy that might not contribute much to the photosynthetic capacity of the tree due to shading. Pruning also changes the trunk shape, with greater diameter growth occurring higher on the trunk than in unpruned trees. The maximum trunk volume growth was achieved by limiting the length of pruned stem to 22 percent of the total tree height in 2004 and to 23 percent of the total tree height over the 4 years. Future tree measurements will determine if trees subjected to the most severe pruning will eventually reach the same size as less severely pruned trees. Tree growth reductions that occurred when trunks were pruned above 25 percent of total tree height, as shown in this study, are inconsistent with the Oregon State University Extension recommendation to limit pruning to 50 percent of total height (Hibbs 1996).

Lower intensity pruning might increase pruning costs, because there will be more pruning events before an 18-ft branch-free trunk is achieved than with higher intensity pruning. Lower intensity pruning will also result in larger branches being pruned, which increases labor costs and results in less clear wood.

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

Treatment	Pruning height* (ft from ground)						Actual percentage of total tree height that was pruned trunk in March				
	1999	2000	2001	2002	2003	2004	2000	2001	2002	2003	2004
1 Check	6	6	6	6	6	6	24.3	15.7	13.7	12.9	11.7
2	6	6	9	12	15	18	22.2	22.9	26.1	28.1	30.5
3	6	9	12	15	18	18	33.7	29.3	32.0	35.3	32.2
4	6	12	15	18	18	18	47.3	39.4	35.2	33.5	30.0
5†	6	9	12	15	18	18	33.7	31.5	34.8	38.7	35.0
LSD (0.05)							2.7	2.1	3.5	3.0	3.4

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

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Figure 1. Poplar tree annual growth increment in 2004 in response to pruning severity, Malheur Experiment Station, Oregon State University, Ontario, OR.

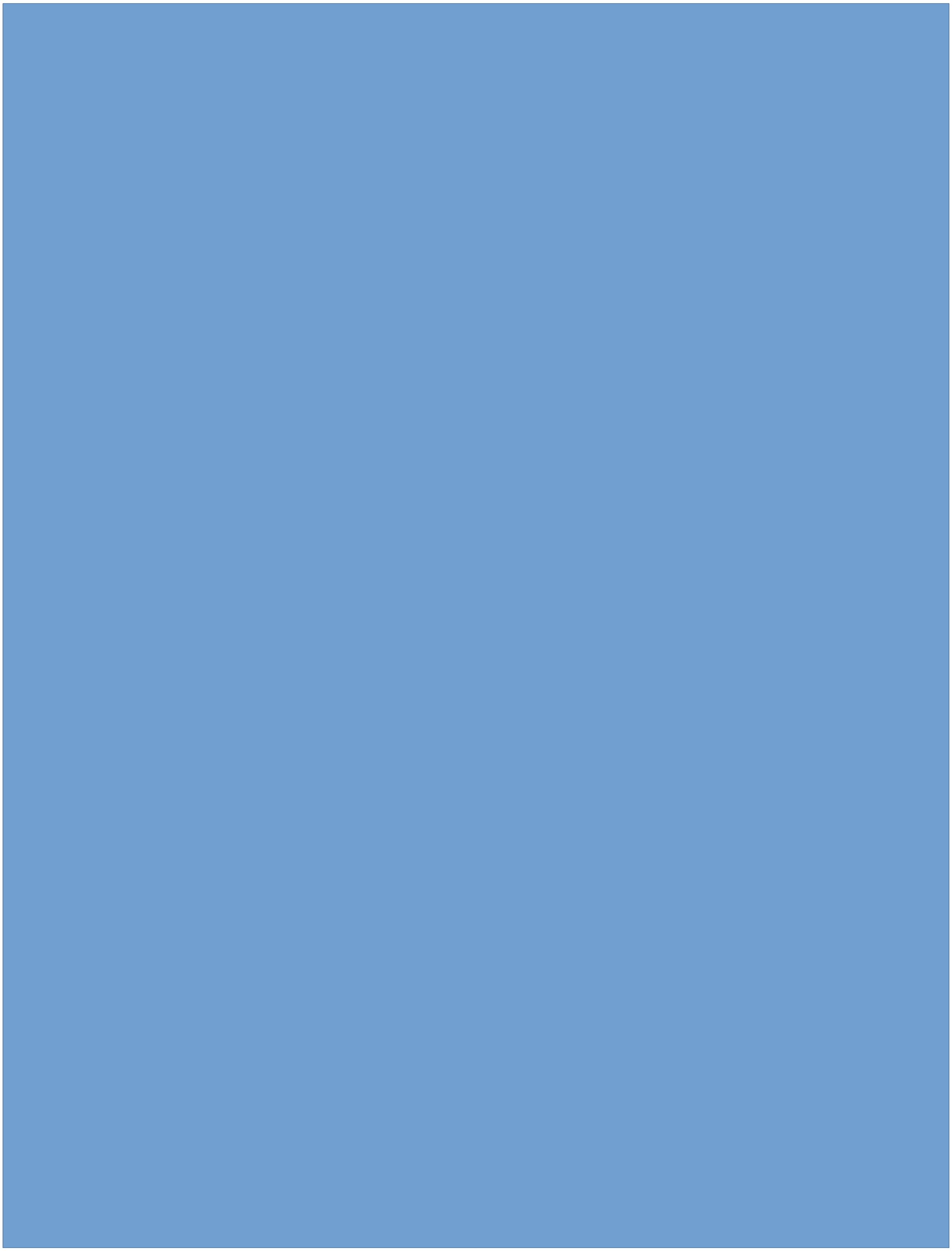

Figure 2. Poplar tree 5-year (2000-2004) growth in response to pruning severity, Malheur Experiment Station, Oregon State University, Ontario, OR.

SOYBEAN PERFORMANCE IN ONTARIO IN 2004

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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. This line was crossed at Corvallis with productive lines to produce OR 6 and OR 8, among others. At this point, the development moved to Ontario, Oregon. The later two lines were crossed at our request for several years with early-maturing high-yielding semi-dwarf lines by R.L. Cooper (USDA, Agriculture Research Service, Wooster, OH) to produce semi-dwarf lines with potential adaptation to the Pacific Northwest. Selection criteria at the Malheur Experiment Station (MES) 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 5 F5 lines that were originally bred and selected for adaptation to eastern Oregon. Seed from these selections was planted and evaluated in 1993; 18 selections were found promising and selected for further testing in larger plots from 1994 through 1999. Of the 18 lines, 8 were selected for further testing. In 1999, selections from one of the MES lines were made by P. Sexton at the Central Oregon Agricultural Research and Extension Center (COAREC) in Madras, Oregon. Sixteen of these Madras selections were chosen for further testing. In 2000, selections were made from six of the 1992 MES lines and from OR-6. This report summarizes work done in 2004 as part of the continuing breeding and selection program to adapt soybeans to eastern Oregon.

Methods

The trial was conducted on a Greenleaf silt loam previously planted to wheat. Forty lbs of nitrogen, 100 lb of sulfur, 2 lb of copper, and 1 lb of boron were broadcast in the fall of 2003. The field was then disked twice, moldboard plowed, groundhogged twice, and bedded to 22-inch rows.

Five commercial cultivars, 5 older lines selected at MES in 1992, 9 lines selected in 1999 at the COAREC from a MES line, and 24 lines selected in 2000 at MES were planted in plots 4 rows by 25 ft.

The plots were arranged in a randomized complete block design with four replicates. The seed was planted on May 20 at 200,000 seeds/acre in rows 22 inches apart. Rhizobium japonicum soil implant inoculant was applied in the seed furrow at planting. Emergence started on June 1. The field was furrow irrigated as necessary. The field was sprayed on August 3 and August 11 with dimethoate at 0.5 lb ai/acre for lygus bug and stinkbug control.

Plant height and reproductive stage were measured weekly for each cultivar. Prior to harvest, each plot was evaluated for lodging and seed shatter. Lodging was rated as the degree to which the plants were leaning over (0 = vertical, 10 = prostrate). The middle two rows in each four-row plot were harvested on October 8 using a Wintersteiger Nurserymaster small plot combine. Beans were cleaned, weighed, and a subsample was oven dried to determine moisture content. Dry bean yields were corrected to 13 percent moisture. Variety lodging, plant population, yield, and seed count were compared by analysis of variance. Means separation was determined by the protected least significant difference test.

Results and Discussion

Yields in 2004 ranged from 44.2 bu/acre for ‘OR-8’ to 70.5 bu/acre for ‘M12’ (Table 1). Several of the lines had seed counts sufficient for the manufacturing of tofu (< 2,270 seeds/lb). Several lines combined high yields, little lodging, and early maturity. Considerable yield advantages were obtained through continued selection.

Table 1. Performance of soybean cultivars ranked by yield in 2004, Malheur Experiment Station, Oregon State University, Ontario, OR. Cultivars M92-085 through M92-350 are from single plant selections made at the Malheur Experiment Station in 1992. Cultivars M1 through M16 are from single plants selected from M92-330.

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

Potato Variety Trials 2004

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Introduction

New potato varieties were evaluated for their productivity and usefulness for processing. Potatoes are grown under contract in Malheur County, Oregon for potato processors to produce frozen products for the food service industry. There is very little production for fresh pack or open market, and very few growers have potato storage buildings on their farms. There is also no production of varieties for making potato chips. Potato seed is not produced in Malheur County because high populations of aphids result in virus infection in the tubers.

The varieties grown for processing are mainly 'Ranger Russet', 'Shepody', and 'Russet Burbank'. Harvest begins in July, and potatoes go to processing plants directly from the field. Yields are limited by "early die" syndrome, which causes early senescence of the vines. Early die is caused by a complex of soil pathogens, including bacteria, nematodes, and fungi, and is worse when crop rotations between potato crops are short.

Small acreages of new varieties or advanced selections are sometimes contracted to study the feasibility of expanding their use. To displace an existing processing variety, a new potato variety needs to have several outstanding characteristics. The yield should be at least as high as the yield of Russet Burbank. The tubers need to have low reducing sugars for light, uniform fry color, and high specific gravity. A new variety should be resistant to tuber defects or deformities caused by disease, water stress, or heat. It should begin tuber bulking early if it is a variety for early harvest. Or, if it is a late-harvest variety, it should be resistant to early die.

Potato variety development trials at Malheur Experiment Station (MES) in 2004 included the Western Regional Early Harvest Trial with 20 entries, the Western Regional Late Harvest Trial with 20 entries, the Oregon Statewide Trial with 29 entries, the Oregon Preliminary Yield Trial with 131 entries, a Malheur Preliminary Yield Trial of 6 strains selected in previous 8-Hill trials at MES, and an 8-Hill trial of 84 clones from the USDA Agricultural Research Service (ARS) potato breeding program at Aberdeen, Idaho. Through these trials and active cooperation with other scientists in Idaho, Oregon, and Washington, promising new lines are bred, evaluated, and eventually released as new varieties.

Materials and Methods

Six potato variety trials were grown under sprinkler irrigation on Owyhee silt loam, where winter wheat was the previous crop in a potato, wheat, corn, wheat, potato rotation. The wheat stubble was flailed and the field was irrigated and disked. A soil test taken on September 16, 2003 showed 37 lb nitrogen (N)/acre in the top 2 ft of soil, and 102 lb available phosphate (P_2O_5), 851 lb soluble potash (K_2O), 29 lb sulfate (SO_4), 1966 ppm calcium (Ca), 463 ppm magnesium (Mg), 87 ppm sodium (Na), 1.6 ppm zinc (Zn), 18 ppm iron (Fe), 4 ppm manganese (Mn), 0.7 ppm copper (Cu), 0.5 ppm boron (B), organic matter 3.5 percent, and pH 7.4 in the top foot of soil. Fall fertilizer was spread to apply 60 lb N/acre, 50 lb P_2O_5/acre, 80 lb K_2O/acre, 57 lb sulfur (S)/acre, 8 lb Zn/acre, 5 lb Cu/acre, and 1 lb B/acre. The field was ripped, Telone II® soil fumigant was injected at 25 gal/acre, and the field was bedded on 36-inch row spacing.

Seed of all varieties was hand cut into 2-oz seed pieces and treated with Tops-MZ®+ Gaucho® dust one to two weeks before planting and placed in storage to suberize. On March 22, 2004, the field was cultivated with a Lilliston rolling cultivator to reshape the hills and to control winter annual weeds and volunteer wheat. On April 2 a soil sample was taken that showed 43 lb N/acre in the top 2 ft of soil, 83 lb available P_2O_5, 688 lb soluble K_2O, 26 lb SO_4, 1,835 ppm Ca, 353 ppm Mg, 69 ppm Na, 1.1 ppm Zn, 5 ppm Fe, 1 ppm Mn, 0.4 ppm Cu, 1.2 ppm B, pH 7.4, and 3.0 percent organic matter in the top foot of soil.

Potato seed pieces were planted in single-row plots using a 2-row cup planter with 9-inch seed spacing in 36-inch rows. Red potatoes were planted at the end of each plot as markers to separate the potato plots at harvest. After planting, hills were formed over the rows with the Lilliston rolling cultivator. Prowl® at 1 lb/acre plus Dual® at 2 lb/acre herbicide was applied as a tank mix for weed control on May 7 and was incorporated with the Lilliston. Matrix® herbicide was applied at 1.25 oz/acre on May 17 and was incorporated with 0.41 inch of rain on the next day, followed by 0.89 inch of additional rain through the end of May.

The Western Regional Early Harvest Trial was planted on April 13, 2004. The Western Regional Late Harvest and the 8-Hill Trial were planted on April 19. The Statewide Trial and the Preliminary Yield Trials were planted on April 26. The Malheur Preliminary Yield Trial, planted on April 26, consisted of 2 entries with sufficient seed available to plant 4 replicates of 30 seed pieces, and 4 entries with enough seed available to plant 2 replicates of 20 seed pieces. The 8-Hill trial was unreplicated with plots 8 seed pieces long, the Oregon Preliminary Yield Trial had 2 replicates with plots 20 seed pieces long, and the Statewide, Western Regional Early Harvest, and Western Regional Late Harvest Trials each had 4 replicates with plots 30 seed pieces long.

Irrigation was applied 21 times (Fig. 1), from June 4 to August 30, with scheduling based on soil water potential. The average readings of 6 Watermark soil moisture sensors (model 200 SS, Irrometer Co. Inc., Riverside, CA) were monitored every 8 hours by a Hansen model AM400 datalogger (M. K. Hansen Co., East Wenatchee, WA). Sensors were installed in the potato row at the seedpiece depth, 10 inches from the top of the hill. The AM400 unit was read frequently through the summer to predict crop water needs; the objective was to apply an irrigation just before the average soil moisture in the potato root zone at the seedpiece depth reached -60 kPa (Fig. 2). Water applied was estimated by recording the sprinkler set duration at 55 psi, and using the nominal sprinkler head output. Crop evapotranspiration (ET_c) was estimated by the U.S. Bureau of Reclamation based on data from an AgriMet weather station at MES.

Fungicide applications to control early blight and prevent late blight infection started with an aerial application of Ridomil Gold® and Bravo® at 1.5 pint/acre on June 12. On June 25, Headline® fungicide was applied; on July 17, Topsin-M® fungicide plus liquid sulfur with 1.5 lb P_2O_5/acre and 0.2 lb Zn/acre was applied by aerial applicator. On August 8, Headline plus 6 lb S/acre was applied to prevent two-spotted spider mite infestation and powdery mildew infection.

Petiole tests were taken every 2 weeks from June 14, and fertilizer was injected into the sprinkler line during irrigation to supply the crop nutrient needs. A total of 103 lb N/acre, 44 lb P_2O_5/acre, 140 lb K_2O/acre, 100 lb SO_4/acre, 0.3 lb Mn/acre, 5 lb Mg/acre, 0.1 lb Cu/acre, 0.1 lb Fe/acre, and 0.5 lb B/acre were applied.

Vines were flailed in the Western Regional Early Harvest Trial on August 16. Western Regional Early Harvest Trial potatoes were lifted August 27 with a two-row digger that laid the tubers back onto the soil in each row. Visual evaluations included observations of desirable traits, such as a high yield of large, smooth, uniformly shaped and sized, oblong to long, attractively russetted tubers, with shallow eyes evenly distributed over the tuber length. Notes were also made of tuber defects such as growth cracks, knobs, curved or irregularly shaped tubers, pointed ends, stem-end decay, stolons that remained attached, folded bud ends, rough skin due to excessive russetting, pigmented eyes, or any other defect, and a note to keep or discard the clone based on the overall appearance of the tubers.

Tubers were placed into burlap sacks and hauled to a barn where they were kept under tarps until grading. After grading, a 20-tuber sample from each plot in the Western Regional Early Harvest Trial was evaluated for tuber quality traits for processing. Specific gravity was measured using the weight-in-air, weight-in-water method. Ten tubers per plot were cut lengthwise and the center slices were fried for 3.5 min in 375°F soybean oil. Percent light reflectance was measured on the stem and bud ends of each slice using a Photovolt Reflectance Meter model 577 (Seradyn, Inc., Indianapolis, IN), with a green tristimulus filter, calibrated to read 0 percent light reflectance on the black standard cup and 73.6 percent light reflectance on the white porcelain standard plate.

The vines were flailed on the late harvest trials on September 21. The vines of most entries had died by the date of the last irrigation on August 30. Potatoes in the Western Regional Late Harvest Trial were dug on October 5. The 8-Hill Trial tubers and the potatoes in the Statewide Trial were dug on October 6-7, and the Preliminary Yield Trial tubers were dug on October 7-8. At each harvest, the potatoes in each plot were visually evaluated as described above. 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 19 through December 6 and evaluated for tuber quality traits, specific gravity, and fry color as described above. Data were analyzed with the General Linear Models analysis of variance procedure in NCSS (Number Cruncher Statistical Systems, Kaysville, UT) using the Fisher's Protected LSD means separation *t*-test at the 95 percent confidence level.

Results and Discussion

At the Malheur Experiment Station in 2004, spring weather was cool and wet, followed by a summer without the usual extreme heat. Dry weather prevented late blight from developing in 2004. No powdery mildew or mite problems were observed in the field. Compared to the 2003 potato trials at this location, overall yields were lower by about 17 percent, and specific gravity of the tubers was lower.

Precipitation during May 1 through September 30 was 2.55 inches, the crop evapotranspiration (ET_c) for the late-harvest trials totaled 26.19 inches, and the trials received 22.15 inches of irrigation plus precipitation, or 84.6 percent of ET_c (Fig. 1). The step increases in the irrigation plus rainfall curve show the 21 sprinkler irrigations applied during the growing season.

The trend of soil moisture during the growing season is shown in Figure 2. The data do not show the individual irrigations because the sensors did not always respond to an irrigation. The irrigation plus rainfall was less than ET_c for the growing season, and the sensor data show that average root zone soil water potential became drier than -60 kPa at least four times during the growing season.

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

Western Regional Early Harvest Trial

In the Western Regional Early Harvest Trial, among the highest in total yields were ‘A92294-6’, ‘Shepody’, ‘AC93026-9Ru’, ‘A93157-6LS’, and ‘TC1675-1Ru’ with total yield ranging from 473 to 546 cwt/acre (Table 1). Of those clones, only TC1675-1Ru had specific gravity above 1.080 g cm^{-3}, a desirable level for processing. In production of marketable tubers for processing (the total of U.S. No.1 plus U.S. No. 2 grades), A92294-6, Shepody, AC93026-9Ru, A9305-10, TC1675-1Ru, and A93157-6LS with marketable yield from 423 to 499 cwt/acre were among the highest in marketable yield.

Western Regional Late Harvest Trial

The highest total yield In the Western Regional Late Harvest Trial was produced by A92294-6, with 658 cwt/acre, and it also produced the highest marketable yield, 632 cwt/acre (Table 2). Among the highest producers of U.S. No. 1 tubers, on a percentage basis, were ‘AC92009-4Ru’, ‘ATX91137-1Ru’, and ‘AO96160-3’, with ATX92230-1Ru, ‘Russet Norkotah’, and ‘A95109-1’, ranging from 84 to 94 percent. Among the highest total U.S. No. 1 tuber producers were ATX92230-1Ru, A93157-6LS, AO96160-3, A92294-6, A9305-10, ‘A95074-6’, and TC1675-1Ru, ranging from 377 to 437 cwt/acre. Shepody, A92294-6, and Russet Burbank produced significantly more U.S. No. 2 tubers than other clones in this trial. In this late-harvest trial, specific gravity of A93157-6LS, AC92009-4Ru, AO96160-3, Ranger Russet, A92294-6, A95074-6, and TC1675-1Ru were among the highest, and acceptable for processing into frozen potato products.

Oregon Statewide Trial

In the Oregon Statewide Trial, the six clones marked with an asterisk were retained by the variety selection committee (Table 3). The clone AO96160-3 will stay in the Statewide Trial and in the Western Regional Trial, ‘AO96164-1’ will advance to the Western Regional Trial, ‘AO96141-3’ and ‘AO98133-2’ will advance to the Western Regional Russet Early and Late Harvest Trials, and ‘AO96162-1’ and 'AO99099-3' will be maintained in the Statewide Trial in 2005. At this location in 2004, AO96160-3, AO96164-1, AO96141-3, AO98133-2, AO96162-1, and AO99099-3 produced among the highest total yields, with a high percentage of U.S. No. 1 tubers, good specific gravity for processing, and light fry colors with no sugar ends. Russet Burbank produced 102 cwt/acre U.S. No. 2 tubers, significantly more than any other entry, and had 30 percent sugar ends.

Oregon Preliminary Yield Trial

In the Preliminary Yield Trial, 126 numbered clones were compared to Russet Burbank, Ranger Russet, Shepody, Russet Norkotah, and 'Umatilla Russet' (Table 4). The Oregon potato variety selection committee kept 11 clones, based on their performance at Hermiston, Klamath Falls, Powell Butte, and Ontario, to advance to the Statewide Trial for 2005. The clones that were advanced were ‘AO96305-3’ , ‘AO96365-2’, ‘AO96370-2’, ‘AO98123-2’, ‘AO98268-5’, ‘AO98282-5’, ‘AO98307-6’, ‘AO99065-2’, ‘AO99081-1’, ‘AO99108-5’, and ‘AO99111-9’. These clones yielded well across the four locations (Hermiston, Klamath Falls, and Powell Butte data are not shown in this report), had a low incidence of undesirable characteristics, had high percentage of U.S. No. 1 tubers, and if selected as promising clones for processing, had high specific gravity, light fry color, and resistance to developing sugar ends in response to stress.

Malheur Preliminary Trial

This was the first year of a Malheur Preliminary Trial, a cooperative project by the Malheur Agricultural Experiment Station and the USDA-ARS. Six clones from previous 8-Hill trials at Malheur were selected for their adaptation to the high early die pressure, heavy soil texture, and hot, dry climate of the Treasure Valley. These clones were compared to Russet Burbank, Ranger Russet, and Umatilla Russet (Table 5). The clones 'A98345-1', 'A91814-2', 'A96112-20', produced a high percentage of U.S. No. 1

tubers, had specific gravity above 1.080 g cm^{-3} (a level desirable for processing), and produced no sugar ends. The clones ‘A99133-6’ and ‘A99123-1’ each produced 5 percent sugar ends, and 'A96783-109LB', produced 15 percent sugar ends.

8-Hill Trial

Eight hills were grown of each of 84 clones selected for long, russet tubers from the Aberdeen ARS potato breeding program, including 17 clones with the LB suffix signifying that they were bred for resistance to late blight. The 84 clones were evaluated for tuber type, yield, grade, and processing quality (Table 6). Yield and grade data were examined for clones having total yield greater than 530 cwt/acre and U.S. No. 1 tubers at 93 percent or higher, without excessive U.S. No. 2, cull, or undersized (less than 4 oz) tubers. Twenty-six of the clones had high yields and produced a high percentage of U.S. No. 1 tubers. Samples of these clones were analyzed for processing quality. The clone ‘COA00329-1’ yielded a total of 695 cwt/acre, with 85 percent U.S. No. 1 tubers, specific gravity of 1.092 g cm^{-3}, and an average fry strip light reflectance of 47.8 percent, which was acceptable for processing, with 0 percent sugar ends. The clone ‘A00345-3LB’ yielded 644 cwt/acre total, with 91 percent U.S. No. 1 grade, specific gravity 1.085 g cm^{-3}, and fry strip light reflectance of 44.5 percent.

Figure 1. Crop evapotranspiration (ET_c) and sprinkler irrigation applied (plus rain) to potato variety trials, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Figure 2. Soil moisture data for sprinkler-irrigated potato variety trials, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 1. Yield, grade, and processing quality of potato entries grown in the Western Regional Early Harvest Trial at Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

†NS= Not significant.

Table 2. Yield, grade, and processing quality of potato entries grown in the Western Regional Late Harvest Trial at Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

†NS = Not significant.

Table 3. Yield, grade, and processing quality of potato entries grown in the Oregon Statewide Trial at Malheur Experiment Station, Oregon State University, Ontario, OR, 2003.

Table 4. Yield, grade, and processing quality of 11 early selections from the 131 entries in the Oregon Preliminary Yield Trial, compared to the 5 check entries, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 5. Yield, grade, and processing quality of early selections from the Malheur Preliminary Trial (in bold) compared to several check entries grown at Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

†Statistics based on 135 entries.

‡ NS = Not significant.

Table 6. Yield, grade, and processing quality for 26 selections from 84 potato clones entered in an unreplicated 8-Hill Trial at Malheur Experiment Station, Oregon State University, 2004.

†Means based on 84 entries.

‡ Means based on 26 entries.

TUBER BULKING RATE AND PROCESSING QUALITY OF EARLY POTATO SELECTIONS

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Introduction

Five potato cultivars ‘Ranger Russet’, ‘Russet Burbank’, ‘Shepody’, ‘Umatilla Russet’, and ‘Wallowa Russet’, and two early selections, ‘A92294-6’, and ‘A93157-6LS’ were compared at six harvest dates in this trial. Ranger Russet, Russet Burbank, and Shepody are currently grown in the Treasure Valley for processing and served as the check varieties. Umatilla Russet and Wallowa Russet are new releases from Oregon State University (OSU) that have yield, grade, and processing quality generally superior to Ranger Russet, Russet Burbank, and Shepody. The numbered clones have performed well in several previous variety trials at this location, including the Western Regional Early Harvest Trial. The first objective of this study was to quantify the tuber bulking rate of potato cultivars that are currently grown, and some numbered clones that may soon be released, and to compare their suitability for production of early harvest potatoes for processing directly from the field. The second objective was to determine which, if any, of these clones could continue to bulk tubers late in the season.

Materials and Methods

The soil was Owyhee silt loam where the previous crop was winter wheat. The wheat stubble was flailed and the field was irrigated and disked. A soil test taken on September 16, 2003 showed 37 lb nitrogen (N)/acre in the top 2 ft of soil, and 102 lb available phosphate (P2O5), 851 lb soluble potash (K2O), 29 lb sulfate (SO4), 1966 ppm calcium (Ca), 463 ppm magnesium (Mg), 87 ppm sodium (Na), 1.6 ppm zinc (Zn), 18 ppm iron (Fe), 4 ppm manganese (Mn), 0.7 ppm copper (Cu), 0.5 ppm boron (B), organic matter 3.5 percent, and pH 7.4 in the top foot of soil. Fall fertilizer was spread to apply 60 lb N/acre, 50 lb P2O5/acre, 80 lb K2O/acre, 57 lb sulfur (S)/acre, 8 lb Zn/acre, 5 lb Cu/acre, and 1 lb B/acre. The field was ripped, Telone II® soil fumigant was injected at 25 gal/acre, and the field was bedded on 36-inch row spacing.

Potato seed was obtained from the OSU Potato Variety Development program at Powell Butte, and the USDA/Agricultural Research Service (ARS) potato program at Aberdeen, Idaho. Seed of Ranger Russet was commercial certified seed from eastern Oregon, and seed of Umatilla Russet was commercial certified seed from central Oregon. Seed was cut by hand into approximately 2-oz pieces, treated with Tops-MZ® plus Gaucho® seed treating dust, and counted into bags of 15 seed for each row of the 2-row plots.

The potato clones were planted on April 13, with rows spaced 36 inches apart and 9-inch spacing between seed pieces in the row. The soil condition was excellent, with good tilth and good soil moisture. The soil temperature at the seed piece depth, 10-inches, was 56°F. The experiment was laid out in a split-plot design, with the harvest dates replicated four times as main plots within blocks and the varieties randomized in each subplot. This was accomplished by planting the rows so that the six harvest date passes through the four replicates would include all of the varieties.

A two-row per bed configuration was started at planting by leaving off the center furrowing shovel of the two-row planter. On May 6, the two-row beds were formed with a spike harrow pulling wide shovels to clean the furrows and form the shoulders of the beds, and dragging a heavy chain to smooth and flatten the top of the bed. The tool bar on back of the bed harrow also carried shanks and spools of drip tape to install a drip tape at 2- to 3-inches depth directly above each potato row. The drip tape was 5/8-inch diameter, with 5-mil wall thickness, 6-inch emitter spacing, 0.22 gal/min/100-ft flow rate (T-tape, T-Systems International, San Diego, CA).

Soil water potential was measured with six Watermark sensors Model 200SS (Irrometer Co. Inc., Riverside, CA) installed in the potato row at the seed piece depth and connected to an AM400 data logger (M.K. Hansen, East Wenatchee, WA) that recorded soil water potential every 8 hours. Water potential readings were also recorded manually from the data logger. Irrigations were scheduled to avoid soil water potential at the root zone dropping below -30 kPa. Crop evapotranspiration (ETc) was estimated by an automated AgriMet (U.S. Bureau of Reclamation, Boise, ID) station located about 0.5 mile away on the Malheur Experiment Station.

Prowl® at 1 lb/acre plus Dual® at 2 lb/acre was applied on May 7, before any potato plants had emerged, and was incorporated with the bed harrow. Matrix® herbicide was applied at 1.25 oz/acre on May 17, and was incorporated by 0.41 inch of rain on the next day, followed by 0.89 inch additional rain through the end of May. Fungicide applications to control early blight and prevent late blight infection started with an aerial application of Ridomil Gold® and Bravo® at 1.5 pint/acre on June 12. On June 25, Headline® fungicide was applied; on July 17, Topsin-M® fungicide plus liquid S with 1.5 lb P_2O_5/acre and 0.2 lb Zn/acre was applied by aerial applicator. On August 8, Headline plus 6 lb S/acre was applied to prevent two-spotted spider mite infestation and powdery mildew infection. No fertilizer was applied to the field in the spring. Petiole tests were taken every 2 weeks from June 11, and fertilizer was injected into the drip system during irrigation to supply the crop nutrient needs (Table 1).

Approximately 40 percent emergence was noted in the trial on May 12. On June 22, the first tubers were dug from one plot in each replicate. Tubers were sorted by weight and tubers in each weight category were counted and weighed. On July 13, tubers were harvested from each replicate, and graded by the U.S. No. 1 and No. 2 for processing standards, sorted by weight, and counted and weighed in each weight category. Specific gravity and length-to-width ratio were measured using a sample of 10 tubers, and fry color was measured on a sample of 20 tubers from each plot. The subsequent harvests, on August 3, August 24, September 14, and October 5, followed the same procedure as the second harvest.

Yield and quality results data were compared using analysis of variance (Number Cruncher Statistical Systems, Kaysville, UT). The tuber bulking rate over time was evaluated using the equation: y = A+B / (1+C-Dt) , where y is the tuber yield in cwt/acre, A, B, C, and D are the potato tuber bulking growth parameters, and t is the time in days after planting (DAP). A suitable value for the exponential variable D was found by preliminary regressions on all the varieties. An average tuber initiation date for all clones was found by dividing the yield of the first harvest by the cwt/acre/day bulking rate between the first and second harvests. The resulting tuber initiation (zero yield) date was 59.9 DAP.

Results and Discussion

The 2004 growing season was cool and rainy in April and May and lacked the usual prolonged heat in the summer months. The total amount of irrigation water applied through the drip tape fell behind potato crop evapotranspiration (ETc) through the growing season, with a total of 15.22 inches of applied irrigation plus rain, and a total accumulated ETc of 27.60 inches (Fig. 1). The soil moisture sensors showed an early season moisture deficit (Fig. 2). This was due to the early season water being only small rainfall events and irrigation beginning June 4. Through the period from 56 to 113 DAP, the sensors indicated wetter soil in the crop root zone than the optimum soil water potential for drip-irrigated potato of -30 kPa, despite the irrigations being less than the amount required to match ETc. The soil was intentionally allowed to become drier after August 31, 140 DAP, to avoid rotting the tubers after vine senescence.

Because the crop root zone remained moist through the growing season, the plants were not stressed and the fry color light reflectance was uniformly 40 percent or higher, except for the stem-end light reflectance of Russet Burbank from the final harvest (Table 2). Very few sugar ends were encountered in frying the samples. In the fourth harvest, 132 DAP, one sugar end was found in A93157-6LS out of 80 tubers fried, or 1.25 percent. In the fifth harvest, 153 DAP, one sugar end was found in Russet Burbank. In the sixth harvest, 174 DAP, one sugar end was found in Russet Burbank, and one in Shepody.

Potato clones varied in yield and the size distribution of the tubers at the three latest harvest dates (Tables 2 and 3). Among the potatoes tested, A92294-6 was the heaviest bulking clone when harvested 132 DAP, with 466 cwt/acre total yield, and 90 percent U.S. No. 1 tubers. At 153 DAP, A93157-6LS with 512 cwt/acre and A92294-6 with 494 cwt/acre were the highest in total yield.

Growers can only plant cultivars that have seed available and that have been accepted by processing companies for contract production. Processors want specific gravity above 1.080 to help assure quality products. Processors prefer tubers with a length/width ratio of about 1.8 to 2.0, so that French fry production is efficient. At present, seed is available for Wallowa Russet, Umatilla Russet, Shepody, and Ranger Russet. When the bulking rate of Wallowa Russet, Umatilla Russet, Shepody, and Ranger Russet are compared at the three latest harvest dates, Wallowa Russet has a yield advantage, producing significantly more than the currently grown cultivars, except for Ranger Russet at 153 DAP. Newer clones, which are not yet released and available to growers, such as A92294-6 and A93157-6LS, had even higher productivity, with 568 and 512 cwt/acre total yield, respectively, at 174 DAP (Table 2).

The tuber bulking rate for total yield, U.S. No. 1, and Marketable categories was plotted over time and evaluated using the equation given above (Figs. 3-9). The U.S. No. 1 category includes all smooth tubers, even undersized tubers less than 4 oz. The Marketable category consists of the U.S. No. 1 and U.S. No. 2 tubers over 4 oz (Figs. 3-9). Early in the growing season, from tuber initiation until tubers exceeded 4 oz, the total yield was the same as the U.S. No. 1 yield, and the bulking rate was generally linear. Where the Marketable yield line crosses the U.S. No. 1 yield line indicates the DAP when U.S. No. 2 tubers outweighed the undersized tubers for each clone (Figs. 3-9).

In previous work (Shock et al. 2002) we showed that early dying of potato vines in mid-August can be a major factor limiting potato productivity in Malheur County, because it limits the ability of tubers to continue to bulk late in the growing season. In the current work, the commercial varieties failed to have substantial marketable yield increases after mid-September, 153 DAP (Figs. 5-7, 9). The lack of increase in marketable yield after 153 DAP was noted for Ranger Russet, Russet Burbank, Shepody, and Umatilla Russet (Figs. 5-7, 9). In contrast, A92294-6, A93157-6LS, and Wallowa Russet continued their upward trends in marketable yield to 174 DAP (Figs. 3, 4, 8) finishing with 568, 512, and 482 cwt/acre, respectively. These clones deserve special attention in future trials and possible tests for resistance to the component pathogens of the early die disease syndrome.

Shepody and Ranger Russet are not especially suitable as early harvest cultivars based on yield. Other clones included in this trial bulked fairly early (Figs. 5-7, 9). From the Western Regional Early Harvest potato variety trials in Ontario over the past few years, several other new clones have also shown promise (data not shown).

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Table 1. Fertilizer applied through the drip irrigation system in response to petiole tests on potato clones and cultivars grown under drip irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 2. Tuber yield, grade, length-to-width ratio, specific gravity, and fry color of five potato clones and six potato varieties that grew until vine removal on August 24, September 13, or October 4, and subsequent harvest on August 24, September 14, or October 5 (Hrv 4, 5, 6), Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 3. Tuber grade and size distribution of five potato clones and six potato varieties that grew

until vine removal on August 24, September 13, or October 4, and subsequent harvest on August 24, September 14, or October 5 (Hrv 4, 5, 6), Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Figure 1. Irrigation water applied through the growing season compared to crop evapotranspiration (ETc) estimated by an AgriMet weather station, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Figure 2. Soil water potential (kPa) measured by Watermark sensors during the irrigation period of drip-irrigated potato clones, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Figure 3. Tuber bulking over time for potato clone A92294-6, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Figure 4. Tuber bulking over time for potato clone A93157-6LS, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Figure 5. Tuber bulking over time for Ranger Russet, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Figure 6. Tuber bulking over time for Russet Burbank, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Figure 7. Tuber bulking over time for Shepody, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Figure 8. Tuber bulking over time for Wallowa Russet, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Figure 9. Tuber bulking over time for Umatilla Russet, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Planting Configuration and Plant Population Effects on Drip-Irrigated Umatilla Russet potato Yield and Grade

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Introduction

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

By placing two rows on a single bed, plants would be spread apart over the soil surface. They should not come immediately into competition with each other for sunlight during June, increasing yield potential. Spreading the plants across the bed could allow a higher plant population, which might enhance yield and reduce the number of oversize potatoes. Furthermore, the distribution of plants across the soil surface would provide better soil shading during June, a factor that might result in better tuber quality.

When potato seeds are planted directly in line with the drip tape, the roots and new tubers are directly in the most saturated part of the soil. By placing the drip tape offset from the seed, roots and tubers would develop in a less saturated part of the potato bed, favoring tuber quality.

Methods

Both Years

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

Irrigations were controlled by a CR10 data logger (Campbell Scientific, Logan, UT) connected to a multiplexer that provided connections for two Watermark (Irrometer Co. Inc., Riverside, CA) soil moisture sensors in each plot. The sensors were installed in a plant row at the seed piece depth. The data logger was connected through relays to a 24VAC solenoid valve for each treatment. The drip tape on each set of 4 plots of a treatment was plumbed through 0.5-inch PVC pipe to 6 solenoid valves supplied with water under constant pressure. The soil moisture sensors were read by the data logger every 3 hours. At midnight and noon the data logger calculated the average sensor readings for each treatment. If the average soil water potential for a treatment was below -30 kPa, the valve opened for 3 hours to apply a 0.2-inch irrigation. Crop evapotranspiration (ETc) was estimated by an automated AgriMet (U.S. Bureau of Reclamation, Boise, ID) station located about 0.5 mile away on the Malheur Experiment Station.

The vines were flailed from the potato plants on October 2, 2003, and on September 21, 2004. The potatoes were dug on October 9, 2003 and on September 29, 2004. The tubers from 15 ft of the center 2 rows of each 4-row plot were bagged and graded. Data were statistically analyzed using the ANOVA procedure in NCSS (Number Cruncher Statistical Systems, Kaysville, UT).

2003 Trial

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

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

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

2004 Trial

The procedures were similar for the 2004 trial. The soil was Owyhee silt loam where the previous crop was winter wheat. The wheat stubble was flailed and the field was irrigated and disked. A soil test taken on September 16, 2003 showed 37 lb N/acre in the top 2 ft of soil, and 102 lb available P_2O_5, 851 lb soluble K_2O, 29 lb sulfate (SO_4), 1966 ppm Ca, 463 ppm Mg, 87 ppm Na, 1.6 ppm Zn, 18 ppm Fe, 4 ppm Mn, 0.7 ppm Cu, 0.5 ppm B, organic matter 3.5 percent, and pH 7.4 in the top foot of soil. Fall fertilizer was spread to apply 60 lb N/acre, 50 lb P_2O_5/acre, 80 lb K_2O/acre, 57 lb S/acre, 8 lb Zn/acre, 5 lb Cu/acre, and 1 lb B/acre. The field was ripped, Telone II soil fumigant was injected at 25 gal/acre, and the field was bedded on 36-inch row spacing.

Potato seed of Umatilla Russet was commercial certified seed from central Oregon. Seed was cut by hand into approximately 2-oz pieces, treated with Tops MZ plus Gaucho seed-treating dust. The potatoes in plots with four rows per bed were planted on April 29, and the two-row beds were planted on April 30. On May 1, the beds were formed with a spike harrow pulling wide shovels to clean the furrows and form the shoulders of the beds, and dragging a heavy chain to smooth and flatten the top of the bed. The drip tape was installed on May 5 and 6, at 2- to 3-inches depth. The drip tape was 5/8-inch diameter, with 5-mil wall thickness, 6-inch emitter spacing, 0.22 gal/min/100 ft flow rate (T-tape, T-Systems International, San Diego, CA). Irrigations began on June 16.

Prowl at 1 lb/acre plus Dual at 2 lb/acre was applied on May 7, 2004 before any potato plants had emerged, and was incorporated with the bed harrow. Matrix herbicide was applied at 1.25 oz/acre on May 17, and was incorporated by 0.41 inch of rain on the next day, followed by 0.89 inch of additional rain through the end of May. Fungicide applications to control early blight and prevent late blight infection started with an aerial application of Ridomil Gold and Bravo at 1.5 pint/acre on June 12. On June 25, Headline® fungicide was applied, on July 17, Topsin-M fungicide plus liquid sulfur with 1.5 lb P2O5/acre and 0.2 lb Zn/acre was applied by aerial applicator. On August 8, Headline plus 6 lb S/acre was applied to prevent two-spotted spider mite infestation and powdery mildew infection. No fertilizer was applied to the field in the spring. Petiole tests were taken every 2 weeks from June 11, and fertilizer was injected into the drip system during irrigation to supply the crop nutrient needs.
Fertilizer solution was injected into the drip system in response to bi-weekly petiole tests. The total fertilizer applied from June 19 to August 14, both through the drip system and by aerial application, was 108 lb N/acre, 28 lb P2O5/acre, 12 lb K2O/acre, 14 lb SO4/acre, 40 lb S/acre, 0.03 lb Ca/acre, 0.5 lb Mg/acre, 0.61 lb Zn/acre, 1.15 lb Mn/acre, 0.69 lb Cu/acre, 0.06 lb Fe/acre, and 0.01 lb B/acre.

Results and Discussion

2003 Results

In 2003, the low-population (18,150 plants/acre), 36-inch hills with drip tape configuration yielded 556 cwt/acre, significantly more than the 470 cwt/acre total yield in the high-population (24,200 plants/acre), 36-inch hills with drip tape configuration (Table 2).

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

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

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

The yield of U.S. No. 2 tubers was significantly greater with the low plant population. The high plant population standard configuration produced the lowest U.S. No. 2 yield, but that treatment also produced the most undersize tubers of less than 4 oz.

2004 Results

In 2004, there was a significant interaction between population and configuration for percentage of U.S. No. 1 tubers. There was a higher percentage of U.S. No. 1 in the low population with 2 rows of potato plants on a 72-inch bed with 2 drip tapes offset 7 inches inside the row, compared to the 2 rows with the drip tape above the row at the low population and 4 rows in a staggered planting with tapes between pairs of rows at the high population (Table 3). This interaction in production of U.S. No. 1 tubers also was seen in the total U.S. No. 1 production in 2004.

Both Years

The averaged data from 2003 and 2004 showed significantly higher total yield for configuration 3 at the high population (Table 4). The high population produced significantly more 4- to 6-oz tubers, and there was a significant year by population interaction. The lowest yield of U.S. No. 2 tubers was produced by the high population in two rows per bed with drip tape above the row (configuration 1).

The soil water remained adequate all season, since the soil water potential remained in the ideal range for all treatments (Fig. 1).

The average water applied by the drip-irrigation systems is one of the interesting aspects of this trial. The total amount of water applied by the drip systems plus rainfall averaged only 15.76 inches, 66.3 percent of the estimated potato evapotranspiration (23.78 inches) from May 25 to September 3 of 2004 (Fig. 2). This result suggests that drip irrigation is a very efficient method for applying limited amounts of water for potato production.

Figure 1. Average soil water potential of six different drip-irrigation treatments for potato, 2004, Malheur Experiment Station, Oregon State University, Ontario, OR.

Figure 2. Cumulative irrigation water plus rainfall for six different drip-irrigation treatments for potato compared with the accumulated potato evapotranspiration from May 25 through September 3, 2004, Malheur Experiment Station, Oregon State University, Ontario, OR.

Table 1. Relationship of planting configuration treatments in the planting configuration trial to a common potato production planting configuration, Malheur Experiment Station, Oregon State University, Ontario, OR, 2003 and 2004.

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

Table 3. Yield and grade of Umatilla Russet grown at two plant populations and three planting configurations with respect to the drip tape, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 4. Yield and grade of Umatilla Russet grown at two plant populations and three planting configurations with respect to the drip tape, averaged over two years, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

† Not Significant at alpha = 0.05.

‡ Becomes significant at this alpha level.

A SINGLE EPISODE OF WATER STRESS REDUCES THE YIELD AND GRADE OF RANGER RUSSET AND UMATILLA RUSSET POTATO

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Introduction

Deficit irrigation is a strategy where crops are allowed to sustain some degree of water deficit in order to reduce costs and potentially increase revenues. English and Raja (1996) described three deficit irrigation case studies where the reductions in irrigation costs are greater than the reductions in revenue due to reduced yields. In these case studies deficit irrigation can lead, in principle, to increased profits when water supplies are limited.

Deficit irrigation has been used successfully with a number of crops. Shock et al. (1998) reported that deficit irrigation of potatoes could be difficult to manage because reductions in tuber yield and quality can result from even brief periods of water stress. However, in some circumstances potatoes can tolerate limited deficit irrigation before tuber set without significant reductions in tuber external and internal quality.

It is generally recognized that some potato varieties are more drought tolerant than others, that is, they give higher yields of tubers in dry years than other varieties (Joyce et al. 1979). Nevertheless, there is not enough information on the effects of slight or moderate water stress on yield of different varieties of potato. The adoption of new potato cultivars by growers and processors makes it desirable to reexamine deficit irrigation, particularly during tuber development.

The objectives of this study were to 1) determine ‘Umatilla Russet’ and ‘Ranger Russet’ potato responses to a single episode of water stress during tuber bulking, and 2) evaluate the potential for deficit irrigation to improve economic efficiency of potato production in the Treasure Valley under a sprinkler-irrigation system.

Materials and Methods

Two potato varieties (Umatilla Russet and Ranger Russet) were grown under sprinkler irrigation on Owyhee silt loam, where winter wheat was the previous crop in a potato, wheat, corn, wheat, and potato rotation. The wheat stubble was flailed and the field was irrigated and disked. A soil test taken on September 16, 2003 showed 37 lb nitrogen (N)/acre in the top 2 ft of soil, and 102 lb available phosphate (P_2O_5), 851 lb soluble potash (K_2O), 29 lb sulfate (SO_4), 1966 ppm calcium (Ca), 463 ppm magnesium (Mg), 87 ppm sodium (Na), 1.6 ppm zinc (Zn), 18 ppm iron (Fe), 4 ppm manganese (Mn), 0.7 ppm copper (Cu), 0.5 ppm boron (B), 3.5 percent organic matter, and pH 7.4 in the top foot of soil. Fertilizer was spread in the fall to apply 60 lb N/acre, 50 lb P_2O_5/acre, 80 lb K_2O/acre, 57 lb sulfer (S)/acre, 8 lb Zn/acre, 5 lb Cu/acre, and 1 lb B/acre. The field was ripped, Telone II® soil fumigant was injected at 25 gal/acre, and the field was bedded on 36-inch row spacing.

Seed of the 2 varieties was hand cut into 2-oz seed pieces and treated with Tops-MZ+ Gaucho® dust 1-2 weeks before planting and placed in storage to suberize. On March 22 the field was cultivated with a Lilliston rolling cultivator to reshape the hills and to control winter annual weeds and volunteer wheat. On April 2 a soil sample was taken that showed 43 lb N/acre in the top two feet of soil, 83 lb available P_2O_5, 688 lb soluble K_2O, 26 lb SO_4, 1,835 ppm Ca, 353 ppm Mg, 69 ppm Na, 1.1 ppm Zn, 5 ppm Fe, 1 ppm Mn, 0.4 ppm Cu, 1.2 ppm B, pH 7.4, and 3.0 percent organic matter in the top foot of soil.

Potato seed pieces were planted using a 2-row cup planter with 9-inch seed spacing in 36-inch rows. Umatilla Russet was planted on April 19 and Ranger Russet was planted on April 26. After planting, hills were formed over the rows with a Lilliston rolling cultivator. Prowl® at 1 lb/acre plus Dual® at 2 lb/acre herbicide was applied as a tank mix for weed control on May 7 and was incorporated with the Lilliston. Matrix® herbicide was applied at 1.25 oz/acre on May 17 and was incorporated by 0.41 inch of rain on the next day, followed by 0.89-inch additional rain through the end of May 2004.

Under non-water stress conditions irrigation was applied 16 times from June 4 to August 30, with scheduling based on soil water potential (Fig. 1). The average readings of 6 Watermark soil moisture sensors model 200 SS (Irrometer Co. Inc., Riverside, CA) were monitored every 8 hours by a Hansen model AM400 datalogger (M. K. Hansen Co., East Wenatchee, WA). Sensors were installed in the potato row at the seedpiece depth, 10 inches from the top of the hill. The AM400 unit was read daily through the summer to establish when to irrigate, with the objective to apply water before the average soil moisture in the potato root zone at the seedpiece depth exceeded -60 kPa (Fig. 2). Water applied was estimated by recording the sprinkler set duration at 55 psi, and using the nominal sprinkler head output. Crop evapotranspiration (ET_c) was estimated by the U.S. Bureau of Reclamation based on data from an AgriMet weather station on the Malheur Experiment Station.

For the water stressed treatment, a single irrigation was skipped on June 28 during tuber bulking (Fig. 1). Eight rain shelters 21 ft long and 10 ft wide were made from clear polyethylene sheets stretched over PVC pipe. These rain shelters were used to prevent sprinkler irrigation on four plots of Umatilla Russet and four plots of Ranger Russet. The area of each plot was 3 potato plant-rows spaced 3 ft apart, 21 ft long, with only the center 15 ft of the middle row harvested. The statistical design was a randomized complete-block design with four replicates. After the 5-hour, 1.5-inch irrigation, the plastic sheets were removed from the PVC frames.

Fungicide applications to control early blight and prevent late blight infection started with an aerial application of Ridomil Gold® and Bravo® at 1.5 pint/acre on June 12. On June 25, Headline® fungicide was applied; on July 17, Topsin-M® fungicide plus liquid sulfur with 1.5 lb P_2O_5/acre and 0.2 lb Zn/acre was applied by aerial applicator. On August 8, Headline plus 6 lb S/acre was applied to prevent two-spotted spider mite infestation and powdery mildew infection.

Petiole tests were taken every 2 weeks from June 14, and fertilizer was injected into the sprinkler line during irrigation to supply the crop nutrient needs. A total of 103 lb N/acre, 44 lb P_2O_5/acre, 140 lb K_2O/acre, 100 lb SO_4/acre, 0.3 lb Mn/acre, 5 lb Mg/acre, 0.1 lb Cu/acre, 0.1 lb Fe/acre, and 0.5 lb B/acre were applied.

Vines were flailed on September 21 and Umatilla Russet and Ranger Russet tubers were dug on October 5 and 6 with a two-row digger that laid the tubers back onto the soil in each row. Visual evaluations included observations of desirable traits, such as a high yield of large, smooth, uniformly shaped and sized, oblong to long, attractively russetted tubers, with shallow eyes evenly distributed over the tuber length.

Tubers from 15 ft of the middle row of the 3-row plot were picked up. Tubers were placed into burlap sacks and hauled to a barn where they were kept under tarps until grading. Tubers were graded and a 20-tuber sample from each plot was placed into storage. The storage was kept near 90 percent relative humidity and the temperature was gradually reduced to 45°F. Tubers were removed from storage December 7 and evaluated for tuber quality traits, specific gravity, and fry color. Specific gravity was measured using the weight-in-air, weight-in-water method. Ten tubers per plot were cut lengthwise and the center slices were fried for 3.5 min in 375°F soybean oil. Percent light reflectance was measured on the stem and bud ends of each slice using a Photovolt Reflectance Meter model 577 (Seradyn, Inc., Indianapolis, IN) with a green tristimulus filter, calibrated to read 0 percent light reflectance on the black standard cup and 73.6 percent light reflectance on the white porcelain standard plate.

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

Results and Discussion

Precipitation for May 1 through September 30 was 2.55 inches and the crop evapotranspiration (ET_c) totaled 26.19 inches. The potato plants received 22.15 inches of irrigation plus precipitation throughout the full growing season, or 84.6 percent of ET_c (Fig. 1). The step increases in the irrigation plus rainfall curve (control) show the 16 sprinkler irrigations applied during the growing season. For the water stress treatment, 15 irrigation episodes were applied, with a single deficit imposed on June 28 as pointed out by the arrow in Figure 1. The previous irrigation was on June 22 and the first irrigation following stress was on July 4. Rainfall during this time interval was 0.07 inch on June 24 and 0.03 inch on June 30.

The trend of soil moisture during the growing season is presented in Figure 2. The data do not show the individual irrigations because the water did not always penetrate the soil to the sensors. The irrigation plus rainfall was less than ET_c for the growing season, and the sensor data show that average root zone soil water potential became drier than -60 kPa at least four times during the growing season.

Soil water potential at the seedpiece depth was allowed to become drier than -60 kPa at the end of the growing season, due to the risk of tuber decay in this field. Frequent sprinkler irrigations of short duration were applied, as shown in Figure 2. This was necessary to avoid swollen lenticels and the associated possibility of rotting the tubers of the early maturity potato varieties planted in the same field, while continuing to apply a portion of the ET_c requirement for the late maturing entries in shallow moisture increments.

Although mean total yield for both cultivars was not influenced by water treatments tested in this preliminary trial, marketable yield and total yield of U.S. No. 1 tubers were significantly affected by a single episode of water stress during tuber bulking (Table 1). Deficit irrigation substantially reduced the percentage of U.S. No. 1 and over-12-oz tubers, with Ranger Russet showing more pronounced response to water stress than Umatilla Russet.

In this preliminary trial, Umatilla Russet responded positively to applied water for total yield and was the most productive cultivar in total yield, besides the non-significant differences among treatments; this agrees with the results obtained by Shock et al. (2003). However, Ranger Russet showed the highest total U.S. No. 1 and marketable yields under a non-limiting water supply.

Production of marketable tubers for processing (which comprises total U.S. No. 1 plus U.S. No. 2 grades) was significantly affected by a single missed irrigation for both potato cultivars. A single episode of water stress during tuber bulking brought about a reduction of 4.5 percent and 26.0 percent on marketable yield of Umatilla Russet and Ranger Russet, respectively.

Shock et al. (2003) reported that well-watered potato subjected to irrigation deficits during tuber bulking responded with reduced specific gravity. Although nonsignificant differences were found between cultivars under both irrigation treatments for specific gravity in this preliminary study, a slight tendency toward reduced specific gravity was observed for Ranger Russet due to a single episode of water stress during tuber bulking. The specific gravity ranged from 1.079 to 1.084 g cm-3, with Ranger Russet showing mean values above 1.080 g cm-3 when water was applied at a rate as close as possible to ETc, a desirable level for processing into frozen potato products.

Length/width ratio was significantly affected by irrigation deficit, with a reduction of about 9 percent for the Ranger Russet potato cultivar.

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Figure 1. Crop evapotranspiration (ET_c), sprinkler irrigation applied plus rainfall (control), and a single episode of water stress (arrow) during tuber bulking of Ranger Russet and Umatilla Russet potato, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Figure 2. Soil moisture data over time for a sprinkler-irrigated potato trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 1. Mean yield and grade of Ranger Russet and Umatilla Russet sprinkler-stressed potato trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

NS = Not significant.

Irrigation System Comparison For the Production of Ranger Russet and UmatillA Russet Potato

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Introduction

Potato is most often produced using sprinkler irrigation. Over the past 5 years various drip-irrigation layouts have been tested for potato production at the Malheur Experiment Station. One option for drip irrigation that we have not tested in recent years would be to plant potatoes in exactly the same way that potatoes are grown under sprinkler and furrow irrigation in 36-inch beds. Since we were studying drip-irrigation designs, an additional treatment was added to every replicate where potato was grown in conventional beds. Plots of all treatments were lengthened in 2004 so that both ‘Umatilla Russet’ and ‘Ranger Russet’ could be grown in each planting configuration. In addition, sprinkler-irrigated Umatilla Russet and Ranger Russet potatoes were grown alongside the drip irrigation experiment. This allowed a comparison of sprinkler irrigation, drip with conventional 36-inch hilled beds, and drip irrigation with various flat bed configurations.

Methods

Umatilla Russet and Ranger Russet were grown using sprinkler irrigation and 4 drip irrigation layouts at 18,150 plants/acre (Table 1). The drip-irrigation cultural practices are described in Shock et al. “Planting Configuration and Plant Population Effects on Drip-Irrigated Umatilla Russet potato Yield and Grade” found in this report. The sprinkler-irrigation cultural practices are described in Pereira et al. “A SINGLE EPISODE OF WATER STRESS REDUCES THE YIELD AND GRADE OF RANGER RUSSET AND UMATILLA RUSSET POTATO” also found in this report.

Drip tapes were shanked into the beds on May 6. Treatment 2 had a single drip tape shanked in over conventionally hilled potato in single rows in 36-inch beds (Table 1). Treatment 3 had 2 rows 36 inches apart on a nominal 72-inch bed (72 inches furrow to furrow) with a drip tape directly above each row of potatoes (Table 1). Treatment 4 had 2 rows of plants 36 inches apart on a 72-inch bed with the drip tapes offset 7 inches to the inside of the bed from each potato row. Treatment 5 had 4 rows of plants on a 72-inch bed with 16 inches between the pairs of rows, and the paired rows 14 inches apart, with the drip tape centered between the pairs of rows. Plants were staggered in the paired rows.

Planting dates and methods, irrigation management, cultural practices, harvest timing and methods, and grading and quality evaluations are all described in the two preceding reports cited above.

The drip plots were in a completely randomized design with the two varieties as split plots. The replicated sprinkler-irrigated plots were alongside the drip irrigation experiment. For simplicity, data were handled as if the sprinkler-irrigated treatments were part of a completely randomized trial, which was not the design. Data were analyzed with the General Linear Models analysis of variance procedure in NCSS (Number Cruncher Statistical Systems, Kaysville, UT) using the Fisher's Protected LSD means separation t-test at the 95 percent confidence level.

Results and Discussion

The reports cited above describe the soil moisture and water applied. Irrigation plus rainfall varied from 22.15 inches for sprinkler irrigation to 12.59 inches for one of the drip-irrigated treatments (Table 2). More water was applied to the sprinkler treatment than any of the drip treatments and the sprinkler-applied water treatment resulted in the lowest marketable yield per applied water, 13.4 cwt/acre-inch. The drip treatments with the tape in line with the plant row (treatments 2 and 3) produced less marketable yield per applied water than the treatments with the drip tape offset from the plant row (treatments 4 and 5). Averaging over production systems, Ranger Russet produced significantly more yield of applied water (19.98 cwt/acre-inch) than Umatilla Russet (15.88 cwt/acre-inch). There was no significant interaction between irrigation system and variety for yield/water applied in terms of cwt/acre-inch.

The yields for all irrigation systems were relatively low in this trial, a reflection of the poor quality of this site (Table 3). There was a strong interaction between variety and irrigation system. The greatest marketable yield occurred with Ranger Russet grown on a flat bed with a single drip tape for each row of plants (treatment 3). Overall Ranger Russet was more productive under drip irrigation than Umatilla Russet. Ranger Russet was not more productive than Umatilla Russet under sprinkler irrigation (Table 3).

Where the drip tape was shanked directly in line with the potato plants, the production system on flat beds (treatment 3), was 26.7 percent more productive of marketable tubers than the production system with the drip tape in conventional beds (treatment 2).

Table 1. Irrigation systems compared for potato production, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 2. Marketable yield, water applied, and water use efficiency for irrigation systems compared for potato production, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 3. Ranger Russet and Umatilla Russet performance under five irrigation systems, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

DEVELOPMENT OF NEW HERBICIDE OPTIONS FOR WEED CONTROL IN POTATO PRODUCTION

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Introduction

Weed control in potatoes is essential for production of high yielding marketable tubers. Herbicide options in potato production are limited. Outlook®, Spartan®, and Chateau® (previously Valor®) demonstrate great promise for use in potato. Spartan and Chateau represent a mode of action that is not currently used in potatoes and offer excellent hairy nightshade control. Outlook (dimethenamid-p) has the same mode of action as Dual® but controls a wider spectrum of weeds. Trials were conducted to evaluate new herbicides for weed control in potatoes. The results of our research have been provided to herbicide companies, the IR4 program, and state regulators in support of additional herbicide registrations in potatoes. Spartan was registered for use in potato in 2004 and Outlook is registered for use in potato in 2005. Chateau is also registered for use in potato and will be available in limited quantities for commercial evaluation for 2005. The registration of these herbicides gives producers additional tools for controlling weeds and may increase economic returns through improved weed control.

Materials and Methods

Three trials were conducted at the Malheur Experiment Station to evaluate new herbicides for weed control efficacy and crop tolerance in potatoes: Spartan alone and in 2- and 3-way tank mixtures; comparisons of standard 2-way tank mixtures with Chateau or Matrix® added in 3-way tank mixtures; and Outlook in 2- and 3-way tank mixtures. In fall 2003, 50 lb nitrogen (N) and 100 lb phosphorus (P)/acre was applied prior to bedding in all trial areas. On October 17, 2003, Telone II® (20 gal/acre) and Vapam® (20 gal/acre) were applied and the ground was bedded. Potatoes were planted April 27, 2004 in an Owyhee silt loam soil with pH 7.6, 2.7 percent organic matter content, and a cation exchange capacity of 19. 'Russet Burbank' seed pieces were planted every 9 inches in 36-inch-wide rows. Seed pieces were treated with Tops-MZ® plus Gaucho®. Experimental plots were 4 rows wide and 30 ft long. Plots were sidedressed with 102 lb N, 4 lb P, 9 lb potassium (K), 8 lb sulfate, 32 lb elemental sulfur (S), 5 lb zinc (Zn), and 1 lb boron (B)/acre on May 3 and rehilled on May 11. Preemergence herbicides were applied with a CO_2-pressurized backpack sprayer delivering 20 gal/acre at 30 psi and incorporated with approximately 0.5 inch of sprinkler irrigation on May 13. Petiole samples were taken and sent for nitrate analysis on July 13. On July 16, 25 lb N/acre was applied through the sprinkler. Aerial fungicide applications included Bravo® and Ridomil Gold® on June 12, Headline® (12 oz/acre) on

June 26, Topsin-M® (20 oz/acre) plus liquid sulfur (6 lb/acre) on July 17, and Headline (12 oz/acre) plus liquid sulfur (6 lb/acre) on August 8. In addition, 1.5 lb P and 0.2 lb Zn/acre were added to the July 17 fungicide application.

Visual potato injury and weed control were evaluated throughout the growing season and tubers were harvested from the center two rows of each plot on September 13-15. Potatoes were graded for yield and size on September 20-27.

Herbicide screening for activity on dodder

Herbicides were screened in a petri dish assay to determine effects on dodder germination and elongation. Dodder seeds were scarified using sandpaper and 10 seeds were placed in each petri dish. Each dish was treated with 6 ml of water containing herbicides at rates equivalent to what would be applied in the field. Dodder germination was counted 4 and 5 days after treatment (DAT), and dodder shoot length was measured 5 DAT.

Results and Discussion

Spartan alone and in 2- and 3-way tank mixtures

Control of all weeds present in this trial was 93 percent or greater by treatments with Spartan alone or combined with other herbicides (Table 1). Spartan caused potato injury on June 9, consisting of interveinal chlorosis and necrosis on one set of leaves, and injury tended to be greater with higher rates of Spartan (Table 1). No differences in potato yield were observed between herbicide treatments, suggesting that the injury was transient (Table 2).

Comparisons of standard 2-way tank mixtures with Chateau or Matrix added in 3-way tank mixtures

The 2-way tank mixtures provided the same level of control as 3-way tank mixtures including either Chateau or Matrix (Table 3). The exception was the combination of Prowl® plus Eptam®, where pigweed control was increased with the addition of Matrix. The 3-way combination of Prowl, Eptam, and Chateau had lower pigweed and barnyardgrass control than most other treatments. Plots treated with Chateau exhibited severe injury on May 26 (Table 3). Injury symptoms included stunting and crinkling of newly emerged shoots and leaves. Rainfall events at the time of potato emergence may have increased the contact of Chateau with the emerging foliage. Some treatments were still causing significant injury on June 9. In one instance, the combination of Prowl, Eptam, and Chateau yielded lower than Prowl plus Eptam (Table 4). This could have been a result of the early injury when Chateau was in the tank mixture.

Outlook in 2- or 3-way tank mixtures

Outlook combined with Prowl or Sencor® in 2-way tank mixtures or with both in a 3-way tank mixture provided 96 percent or greater control of all weeds (Table 5). Potato yields were not different among herbicide treatments (Table 6).

Herbicide screening for activity on dodder

Only Nortron® suppressed dodder germination compared to the untreated check (Table 7). However, all herbicides except Chateau shortened shoot length compared to the untreated check. Nortron caused the greatest reduction followed by Kerb®, Prowl, Spartan, and Dacthal®. Nortron and Kerb are not registered for use in potato. The fact that Prowl and Spartan reduced dodder shoot growth suggests they may be useful in managing dodder in potatoes. In this trial, both Prowl and Spartan rates were higher than those registered for use in potato. Additional research needs to be done with Prowl and Spartan rates that are used in potato production.

Table 1. Effect of Spartan® alone and in combinations on crop injury and weed control in potato, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment*	Rate	Potato injury 5-26	Potato injury 6-9	Weed control[†] Pigweed[‡]	Common lambsquarters	Hairy nightshade	Kochia	Barnyard grass
	lb ai/acre	------------	------------	------------	%	------------	------------	------------
Untreated check	--	-	-	-	-	-	-	-
Spartan	0.094	0	14	100	100	100	100	98
Spartan	0.14	5	20	100	100	100	100	94
Spartan	0.187	3	20	100	100	100	100	98
Spartan + Prowl	0.094 + 1.0	3	14	100	100	100	100	93
Spartan + Prowl	0.14 + 1.0	6	18	100	100	100	100	100
Spartan + Dual Magnum	0.094 + 1.33	0	11	100	100	100	100	100
Spartan + Dual Magnum	0.14 + 1.33	6	21	100	100	100	100	100
Spartan + Outlook	0.094 + 0.84	3	11	100	100	100	100	100
Spartan + Outlook	0.14 + 0.84	11	15	100	99	100	100	100
Spartan + Eptam	0.094 + 3.94	3	13	100	100	100	100	97
Spartan + Eptam	0.14 + 3.94	4	21	100	100	100	100	99
Spartan + Prowl + Eptam	0.094 + 1.0 + 3.94	3	7	100	100	100	100	99
Spartan + Prowl + Dual Magnum	0.094 + 1.0 + 1.33	0	11	100	100	100	100	100
Spartan + Prowl + Outlook	0.094 + 1.0 + 0.84	9	5	100	100	100	100	100
LSD (P = 0.05)	--	NS	9	NS	NS	NS	NS	NS

*Herbicide treatments were applied preemergence on May 13, 2004.
[†]Weed control evaluations were taken September 2.
[‡]Pigweed species were a combination of Powell amaranth and redroot pigweed.

Table 2. Effect of Spartan® alone and in combinations on potato yield and quality, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

		Potato yield†							
		U.S. No. 1					Total	Total	Total
Treatment*	Rate	4-6 oz	6-12 oz	>12 oz	Total	Percent	No. 2	marketable	yield
	lb ai/acre	cwt/acre				%	cwt/acre		
Untreated check	--	106	113	15	234	65	5	239	359
Spartan	0.094	90	316	62	467	75	70	537	616
Spartan	0.14	102	293	79	474	78	58	532	606
Spartan	0.187	87	316	86	488	77	70	558	623
Spartan + Prowl	0.094 + 1.0	91	289	46	427	73	71	497	583
Spartan + Prowl	0.14 + 1.0	91	298	69	457	74	87	544	609
Spartan + Dual Magnum	0.094 + 1.33	91	287	51	429	72	88	516	584
Spartan + Dual Magnum	0.14 + 1.33	77	306	65	447	75	71	518	592
Spartan + Outlook	0.094 + 0.84	81	290	65	435	74	76	511	586
Spartan + Outlook	0.14 + 0.84	85	295	64	444	73	82	525	601
Spartan + Eptam	0.094 + 3.94	93	296	54	443	74	80	522	598
Spartan + Eptam	0.14 + 3.94	81	319	85	484	78	68	552	617
Spartan + Prowl + Eptam	0.094 + 1.0 + 3.94	102	311	64	476	76	71	547	624
Spartan + Prowl + Dual Magnum	0.094 + 1.0 + 1.33	97	275	39	411	72	83	493	572
Spartan + Prowl + Outlook	0.094 + 1.0 + 0.84	90	290	66	446	75	67	513	590
LSD (P = 0.05)	--	NS	53	37	74	6.8	26	72	63

*Herbicide treatments were applied preemergence on May 13, 2004.
†Potatoes were harvested September 13 to 15. Total marketable yield = total number ones + total number twos.

Table 3. Comparison of standard 2-way tank mixtures with Chateau® or Matrix® added in 3-way tank mixtures for potato crop injury and weed control, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment*	Rate	Potato injury 5-26	Potato injury 6-9	Weed control† Pigweed‡	Weed control† Common lambsquarters	Weed control† Hairy nightshade	Weed control† Kochia	Weed control† Barnyard grass
	lb ai/acre	%						
Untreated check	--	-	-	-	-	-	-	-
Dual Magnum + Sencor	1.33 + 0.5	3	3	99	100	96	100	100
Prowl + Sencor	1.0 + 0.5	0	0	100	100	100	100	100
Dual Magnum + Prowl	1.33 + 1.0	0	0	97	99	99	100	100
Prowl + Eptam	1.0 + 3.94	0	3	93	100	97	100	97
Dual Magnum + Sencor + Chateau	1.33 + 0.5 + 0.048	35	15	100	100	100	100	100
Sencor + Prowl + Chateau	0.5 + 1.0 + 0.048	32	8	99	100	100	100	98
Dual Magnum + Prowl + Chateau	1.33 + 1.0 + 0.048	34	11	99	99	100	100	100
Prowl + Eptam + Chateau	1.0 + 3.94 + 0.048	33	6	93	100	100	100	92
Dual Magnum + Sencor + Matrix	1.33 + 0.5 + 0.0234	1	0	100	100	94	100	100
Sencor + Prowl + Matrix	0.5 + 1.0 + 0.0234	0	0	100	100	98	100	100
Dual Magnum + Prowl + Matrix	1.33 + 1.0 + 0.0234	3	3	100	100	100	100	100
Prowl + Eptam + Matrix	1.0 + 3.94 + 0.0234	0	0	100	100	100	100	100
LSD (P = 0.05)	--	4	5	5	NS	NS	NS	4

*Herbicide treatments were applied preemergence on May 13, 2004.
†Weed control evaluations were taken September 2.
‡Pigweed species were a combination of Powell amaranth and redroot pigweed.

Table 4. Effect of standard 2-way tank mixtures with Chateau® or Matrix® added in 3-way tank mixtures on potato yield and quality, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

		Potato yield[†]							
		U.S. No. 1					Total	Total	Total
Treatment*	Rate	4-6 oz	6-12 oz	>12 oz	Total	Percent	No. 2	marketable	yield
	lb ai/acre	-------------------- cwt/acre --------------------				%	------------- cwt/acre -------------		
Untreated check	--	90	154	4	247	65	20	268	380
Dual Magnum + Sencor	1.33 + 0.5	93	290	69	450	75	76	526	602
Prowl + Sencor	1.0 + 0.5	88	303	68	459	76	67	526	606
Dual Magnum + Prowl	1.33 + 1.0	84	285	87	457	77	70	527	596
Prowl + Eptam	1.0 + 3.94	88	319	87	493	79	64	557	625
Dual Magnum + Sencor + Chateau	1.33 + 0.5 + 0.048	94	290	63	447	74	53	501	602
Sencor + Prowl + Chateau	0.5 + 1.0 + 0.048	103	275	68	445	75	64	509	597
Dual Magnum + Prowl + Chateau	1.33 + 1.0 + 0.048	90	268	66	424	73	60	484	583
Prowl + Eptam + Chateau	1.0 + 3.94 + 0.048	99	272	49	419	74	47	467	568
Dual Magnum + Sencor + Matrix	1.33 + 0.5 + 0.0234	87	294	81	462	74	81	543	624
Sencor + Prowl + Matrix	0.5 + 1.0 + 0.0234	92	306	76	473	76	64	537	625
Dual Magnum + Prowl + Matrix	1.33 + 1.0 + 0.0234	78	315	116	508	78	65	574	649
Prowl + Eptam + Matrix	1.0 + 3.94 + 0.0234	101	284	50	437	72	76	514	603
LSD (P = 0.05)	--	NS	36	28	47	5	30	50	44

*Herbicide treatments were applied preemergence on May 13, 2004.
[†]Potatoes were harvested September 13 to 15. Total marketable yield = total number ones + total number twos.

Table 5. Potato injury and weed control with Outlook®, Prowl H_2O®, and Sencor® combinations, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment*	Rate	Potato injury 5-26	Potato injury 6-9	Weed control[†] Pigweed[‡]	Common lambsquarters	Hairy nightshade	Kochia	Barnyard grass
	lb ai/acre	---%						---
Untreated check	--	-	-	-	-	-	-	-
Prowl H_2O + Outlook	1.0 + 0.656	6	0	98	100	98	100	100
Prowl H_2O + Outlook	1.0 + 0.84	6	0	100	100	100	100	100
Outlook + Sencor	0.656 + 0.5	0	0	100	100	97	100	100
Outlook + Sencor	0.84 + 0.5	1	0	100	100	96	100	100
Prowl H_2O + Outlook + Sencor	1.0 + 0.656 + 0.5	1	0	99	100	100	100	100
Prowl H_2O + Outlook + Sencor	1.0 + 0.84 + 0.5	1	0	100	100	97	100	100
LSD (P = 0.05)	--	5	NS	NS	NS	NS	NS	NS

*Herbicide treatments were applied preemergence on May 13, 2004.
[†]Weed control evaluations were taken September 2.
[‡]Pigweed species were a combination of Powell amaranth and redroot pigweed.

Table 6. Influence of Outlook®, Prowl H_2O®, and Sencor® combinations on potato yield and quality, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment*	Rate	Potato yield[†] U.S. No. 1 4-6 oz	6-12 oz	>12 oz	Total	Percent	Total No. 2	Total marketable	Total yield
	lb ai/acre	--- cwt/acre			---	%	--- cwt/acre		---
Untreated check	--	98	146	9	252	66	16	268	380
Prowl H_2O + Outlook	1.0 + 0.656	91	302	74	467	77	67	534	606
Prowl H_2O + Outlook	1.0 + 0.84	98	304	67	470	75	73	543	628
Outlook + Sencor	0.656 + 0.5	74	316	84	474	77	71	545	619
Outlook + Sencor	0.84 + 0.5	98	280	57	45	75	56	490	575
Prowl H_2O + Outlook + Sencor	1.0 + 0.656 + 0.5	90	279	56	425	72	72	497	589
Prowl H_2O + Outlook + Sencor	1.0 + 0.84 + 0.5	90	288	59	437	75	64	501	584
LSD (P = 0.05)	--	NS	55	30	64	6	26	61	54

*Herbicide treatments were applied preemergence on May 13, 2004.
[†]Potatoes were harvested September 13 to 15. Total marketable yield = total number ones + total number twos.

Table 7. Dodder germination and shoot length in response to herbicides in a petri-dish screening trial, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment*	Equivalent rate	Rate	Dodder Germination 4 DAT	Dodder Germination 5 DAT	Dodder Shoot length†
	lb ai/acre	mg ai/liter	--------------- %	----------------	----mm----
Untreated	--		85	88	58
Prowl	1.5	170	73	73	16
Kerb	2.0	227	90	93	12
Dacthal	5.0	567	83	85	32
Chateau	0.096	11	80	83	61
Matrix	0.0234	2.7	68	75	46
Spartan	0.25	28	87	87	24
Nortron	3.0	340	0	10	1.3
LSD (P=0.05)	--	--	15	16	3.8

*Herbicide treatments were applied in 5 ml of water on August 12, 2004.
†Dodder shoot length was measured only on shoots that had emerged by 4 DAT.

SUGAR BEET VARIETY 2004 TESTING RESULTS

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Introduction

The sugar beet industry, in cooperation with Oregon State University, tests commercial and experimental sugar beet varieties at multiple locations each year to identify varieties with high sugar yield and root quality. A seed advisory committee evaluates the data each year to select the best varieties for sugar beet production. This report provides the agronomic practices, experimental procedures, and sugar beet root yield and quality for the Malheur Experiment Station location of the 2004 trials.

Methods

Sugar beet varieties were entered by ACH Seeds, Betaseed, Hilleshog/Syngenta, Holly Hybrids, and Seedex in 2004. Twenty-nine varieties were tested in the Commercial Trial, and 31 varieties (including the 4 commercial check varieties) were tested in the Experimental Trial. Seed for the Commercial Trial was organized by Amalgamated Sugar Company. Seed of Experimental varieties was sent by the seed companies.

The sugar beet trials were grown on an Owyhee silt loam that had grown winter wheat the year before. The grain stubble was chopped and the field was irrigated and disked, then 60 lb nitrogen (N)/acre, 50 lb phosphate (P_2O_5)/acre, 80 lb potash (K_2O)/acre, 57 lb sulfur (S)/acre, 8 lb zinc (Zn)/acre, 5 lb copper (Cu)/acre, and 3 lb boron (B)/acre were applied according to fall soil sampling results. The field was then disked, ripped, plowed, and groundhogged. On November 7, the soil was fumigated with Telone C17® at 15 gal/acre, and fall bedded on 22-inch rows.

On March 30, the beds were dragged off using a spike-tooth bed harrow with 3.75-inch angle iron furrow slickers. Preplant herbicide Nortron® at 6 pint/acre was applied and incorporated using the bed harrow. Both the Experimental Trial and the Commercial Trial were planted on April 1. Seeds were planted in four-row plots with John Deere model 71 flexi-planter units with double disc furrow openers and cone seeders fed from a spinner divider that uniformly distributed the seed. Plots of each variety were 4 rows wide (22-inch row spacing) by 23 ft long, with a 4-ft alley separating each tier of plots. The seeding rate was 12 viable seed/ft of row. Each entry was replicated eight times in a randomized complete block design.

A soil test taken on April 4, 2004, showed pH 7.8, 2.9 percent organic matter, 32 lb nitrate (NO_3)/acre available in the top 2ft of soil, 20 ppm extractable phosphorus (P), 256 ppm exchangeable potassium (K), 10 ppm sulfate (SO_4), 433 ppm magnesium (Mg), 82 ppm sodium (Na), 4.1 ppm Zn, 5 ppm iron (Fe), 1 ppm manganese (Mn), 0.6 ppm Cu, and 0.8 ppm B.

On April 5 Counter 20CR® was applied in a band over the row at 7.4 lb/acre (5 oz/1,000 ft of row). The first irrigation was applied on April 9, for 24 hours. A 44.5-hour irrigation on April 12 that was applied to wet the seed rows for more uniform germination was followed by 0.9 inch of rain April 19-21. On April 27, Poast® herbicide was applied at 2 pint/acre to control grasses and volunteer wheat. On May 4, a tank mix of Betamix® at 32 oz/acre, Upbeet® at 0.5 oz/acre, and Stinger® at 3 oz/acre was applied for weed control. Seedlings were thinned by hand to 1 plant every 6.4 inches on May 10 and 11. On May 11 the plots of two entries in the Experimental Trial that failed to emerge were replanted with the border variety, PM21.

The field was sidedressed with Temik 15G® at 10 lb/acre on May 13 to control sugar beet root maggot, and the field was irrigated for 24 hours to move the insecticide with the wetting front into the sugar beet seedlings' root zone. On May 25, urea was sidedressed to supply 182 lb N/acre. On May 27 the field was cultivated and recorrugated with 9-inch sweeps ahead of 6-inch angle iron furrow slickers. On June 1, Treflan® herbicide was applied at 1.5 pint/acre and incorporated with the same cultivator.

The field was furrow irrigated with surge irrigation from gated pipe. Irrigation was monitored with Watermark soil moisture sensors Model 200SS (Irrometer Co. Inc., Riverside, CA) connected to an AM400 Hansen datalogger (M.K. Hansen Co., Wenatchee, WA) to maintain the soil water potential wetter than -70 centibar (kPa) at 10-inch depth in the beet row.

A petiole test was taken on June 14, and Thio-Sul® was applied in the irrigation water on June 21 to supply 25 lb N plus 33 lb SO_4/acre. Headline® fungicide was applied at 12 oz/acre by aerial applicator on June 25 for control of powdery mildew. On June 28, a second petiole test was taken and the field was recorrugated the final time. On July 6, 20 lb N/acre, 10 lb P_2O_5/acre, 10 lb SO_4/acre, 0.25 lb Zn/acre, and 0.2 lb B/acre were applied in the irrigation water. A third petiole test was taken on July 12, and on July 15, 5 lb Mg/acre, 7 lb SO_4/acre, and 0.5 lb B/acre were applied in the irrigation water. On July 17, Topsin-M® fungicide at 20 oz/acre was applied by airplane in a spray mixture that included S at 6 lb/acre, P_2O_5 at 1.5 lb/acre, and Zn at 0.2 lb/acre. An aerial application of Headline fungicide at 12 oz/acre plus sulfur at 6 lb/acre was applied on August 8.

The final irrigation was applied on September 2. Visual estimates of curly top virus and powdery mildew foliar symptoms were recorded for each plot in the Experimental Trial on September 10, and for each plot in the Commercial Trial on September 16. Bolted beets were counted when the disease ratings were made.

Sugar beets were harvested from the Experimental Trial on October 13 and 14, and from the Commercial Trial on October 14 and 15. The foliage was flailed and the crowns were removed with rotating knives. All sugar beets in the center two rows of each plot were dug with a two-row wheel-lifter harvester and weighed, and two eight-beet samples were taken from each plot. Samples were delivered each day to the Snake River Sugar factory in Nyssa for laboratory analysis of percent sucrose, nitrate concentration, and conductivity.

The root weight data were examined for outliers as is customary for calculations of sugar beet variety data by Amalgamated in these trials. Observations more than two standard deviations from the mean for each variety were deleted. Sugar sample data were checked for errors in sugar percentages and conductivity. Any erroneous sample readings were deleted from the data set. The companion samples of all missing or deleted sugar data were good, so no plots were lost due to sugar sample errors.

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

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

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

Variety differences in yield, sucrose content, conductivity, percent extraction, and estimated recoverable sugar were calculated using least-squares means analysis. Sugar beet performance in both trials was compared to the check varieties ACH Seeds 'Crystal 217R', Betaseed 'Beta 4490 R', Hilleshog/Syngenta 'HM2986 Rz', and Seedex 'Raptor Rz'. Reports of previous years' Oregon State University variety trials are available online at www.cropinfo.net.

Results

Early stand establishment was slow and erratic. The sixth irrigation, on June 29 (the first irrigation in the wheel furrows), was effective in wetting the soil and the soil moisture sensors responded to the irrigation (Fig. 1). Surge irrigation approximately once a week maintained soil water potential wetter than -60 kPa through most of the growing season.

Powdery mildew infection developed on sugar beet foliage in these trials and in neighboring growers' fields. Curly top virus foliar symptoms were more severe in the beets this year than is usually seen (Table 1). In the Experimental Trial, Beta ‘3YK0019’, Beta ‘4YK0023’, Crystal ‘318R’, and Beta ‘4YK0024’ were among the varieties showing the most severe curly top virus foliar symptoms. SX Raptor RZ, SX ‘1522’, Crystal 217R, and ‘04HX431RZ’ were among the varieties showing the most severe powdery mildew symptoms in the Experimental Trial. In the Commercial Trial, Beta ‘4035R’, Crystal ‘9906R’, Beta ‘4490R’, and Beta ‘4614R’ were among the varieties showing the most severe curly top virus foliar symptoms. Beta ‘4614R’, Crystal 217R, Crystal ‘333R’, and ‘Beta ‘4773R’ were among the varieties showing the most severe powdery mildew symptoms in the Commercial Trial.

Variety results were grouped by seed company for the Commercial Trial (Table 2) and the Experimental Trial (Table 3). Within each seed company's varieties, the varieties are ranked in descending order of estimated recoverable sugar in pounds per acre. The root weights were tared 10 percent in 2004; in previous years, a root tare of 5 percent had been applied. The truck loads of border row beets delivered to the Nyssa factory in 2004 from the same field, dug with the same harvester, ranged from 5 to 7.9 percent tare, and averaged 6.5 percent tare.

Root yield in the Commercial Trial averaged 42.98 tared ton/acre, average sugar content was 17.95 percent, and average estimated recoverable sugar was 13,345 lb/acre. The varieties yielding among the highest estimated recoverable sugar in the Commercial Trial were 'Beta 8600', with 14,867 lb/acre, Holly Hybrids 'Acclaim R’ with 14,217 lb/A, and Seedex ‘Cascade' with 14,192 lb/acre.

Data for the Experimental Trial are reported in Table 3. Root yield in the Experimental Trial averaged 43.37 tared ton/acre, average sugar content was 17.64 percent, and average estimated recoverable sugar was 13,144 lb/acre. The varieties yielding among the highest estimated recoverable sugar in the Experimental Trial were 'HMPM90' with 14,228 lb/acre, ‘HM2993Rz’ with 13,933 lb/acre, '04HX422 R' with 13,920 lb/acre, 'Beta 4YK0024' with 13,760 lb/acre, ‘04HX438 R' with 13,733 lb/acre, ‘HM 2995Rz’ with 13,680 lb/acre, ‘Beta 2YK0016’ with 13,607 lb/acre, and 'HM 2992Rz' with 13,572 lb/acre.

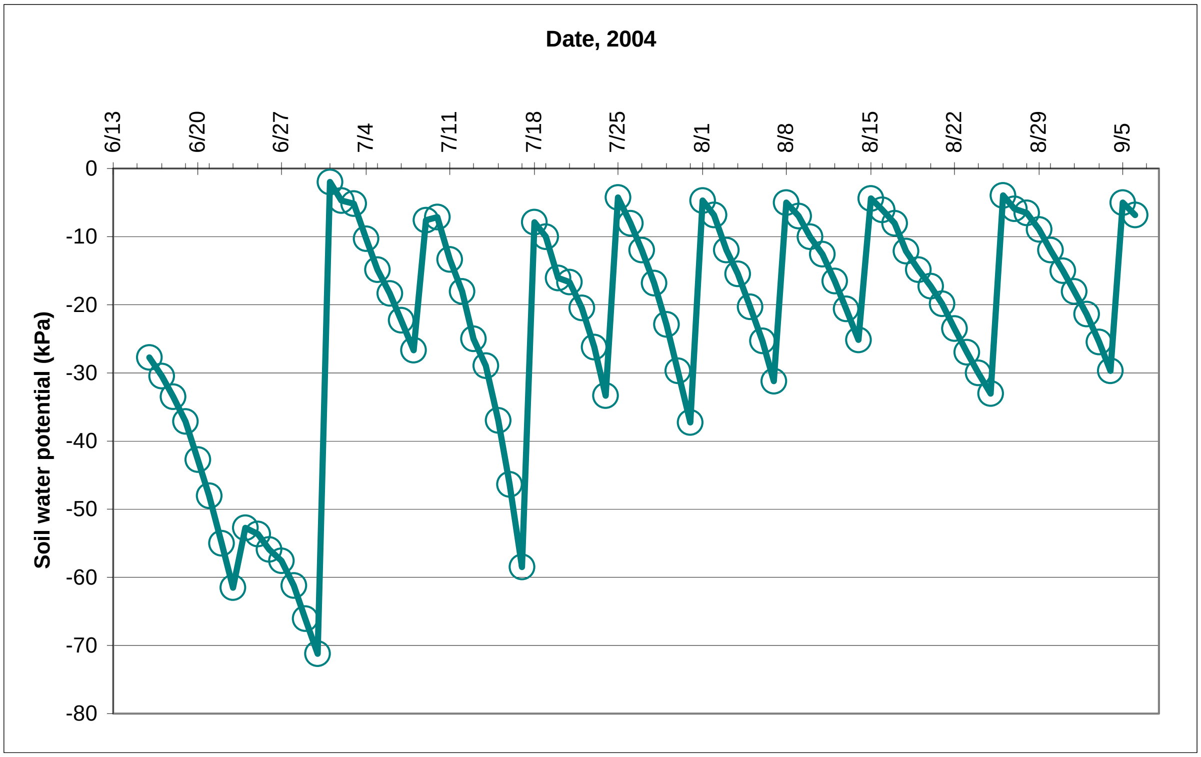

Figure 1. Sugar beet trials average soil water potential of six Watermark soil moisture sensors read by an AM400 Hanson datalogger, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Table 1. Visual evaluations of foliar disease symptoms and bolting in sugar beet varieties, Oregon State University, Malheur Experiment Station, Ontario, OR, 2004.

Experimental Trial			
10 September	CT[†]	PM[‡]	Bolt[§]
HM2986RZ	1.8	1.6	0.0
HM2991 RZ	4.0	1.8	0.0
HM2992 RZ	3.9	1.5	0.0
HM2993 RZ	0.9	1.4	0.0
HM2994 RZ	0.9	1.9	0.0
HM2995 RZ	2.9	1.9	0.0
HM PM90	0.8	1.5	0.0
PM21 replant	1.9	1.2	0.0
PM21 replant	1.5	1.1	0.0
03HX353RZ	1.2	1.8	0.0
04HX422RZ	1.9	1.8	0.4
04HX431RZ	1.3	2.3	7.4
04HX434RZ	1.8	1.8	0.4
04HX436RZ	2.3	2.0	0.0
04HX437RZ	1.6	1.3	1.3
04HX438RZ	2.2	1.9	0.0
SX Raptor RZ	3.6	3.0	0.0
SX1521	2.7	2.1	0.0
SX1522	2.6	2.7	0.0
Crystal 217R	1.8	2.3	0.8
Crystal 316R	1.1	2.0	0.0
Crystal 318R	4.5	1.4	0.0
Crystal 411R	1.4	1.8	0.0
Crystal 412R	1.3	1.4	0.0
Beta4490R	3.6	1.6	0.0
Beta 2YK0016	1.4	1.6	0.0
Beta 3YK0019	5.8	1.9	0.0
Beta 3YK0020	1.5	1.4	0.0
Beta 4YK0023	5.3	1.8	0.0
Beta 4YK0024	4.5	1.1	0.0
Beta 4YK0025	3.6	1.5	0.0
Mean	2.4	1.7	0.3
LSD (0.05)	1.3	0.9	0.8

Commercial Trial			
16 September	CT[†]	PM[‡]	Bolt[§]
HM1642	2.3	2.3	0.0
HM2980RZ	4.1	1.8	0.0
HM2984RZ	1.9	2.4	0.0
HM2986RZ	1.9	2.2	0.0
HM2988RZ	3.8	1.6	0.0
HM2989RZ	2.4	2.3	0.0
HM Alliance	1.4	2.4	0.4
HM Oasis	0.9	1.5	0.0
HM Owyhee	1.2	2.4	0.0
HM PM21	0.8	1.4	0.0
Acclaim RZ	1.8	1.4	0.0
Eagle RZ	2.5	2.0	0.0
HH142 RZ	4.3	1.1	0.0
Meridian RZ	1.9	1.9	0.0
Phoenix RZ	3.3	2.1	0.0
Cascade	0.9	0.9	0.0
Puma	1.2	2.5	0.0
Raptor RZ	4.8	2.5	0.0
ACH Mustang	2.0	2.5	0.0
Crystal 217R	2.3	3.3	0.0
Crystal333R	3.5	3.0	0.0
Crystal9906R	5.8	2.9	0.0
Beta 4035R	6.4	2.8	0.0
Beta 4199R	5.0	2.5	0.0
Beta 4490R	5.8	2.3	0.0
Beta 4614R	5.1	3.8	0.0
Beta 4773R	1.8	3.0	0.0
Beta 8220B	2.9	2.4	0.0
Beta 8600	2.3	1.1	0.0
Mean	2.9	2.2	0.0
LSD (0.05)	1.3	0.8	0.1

[†]Average curly top virus symptom severity rating from 0 (none) to 10.

[‡]Average powdery mildew fungus symptom severity rating from 0 (none) to 10.

[§]Average number of bolted beets per 4-row plot, 23 feet long.

Table 2. Commercial sugar beet variety root yield, sugar content, root quality, recoverable sugar, and nitrate content from varieties entered in the trial at Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

	Root yield	Sugar content	Gross sugar	Conductivity	Extraction	Estimated recoverable sugar		Nitrate content
Variety	ton/acre	%	lb/acre	mmho	%	lb/ton	lb/acre	ppm
ACH Seeds								
ACH Mustang	44.83	17.79	15,931	0.701	85.79	305.1	13,666	119
Crystal 9906R	40.09	17.99	14,415	0.571	87.51	314.8	12,614	102
Crystal 217R	39.05	18.44	14,417	0.661	86.41	318.8	12,457	136
Crystal 333R	36.93	18.34	13,546	0.691	86.00	315.4	11,647	95
Betaseed								
Beta 8600	47.71	17.99	17,158	0.638	86.65	311.8	14,867	106
Beta 4199R	42.97	18.21	15,650	0.678	86.16	313.8	13,482	110
Beta 8220B	43.14	18.19	15,687	0.721	85.59	311.6	13,430	112
Beta 4035R	44.19	17.50	15,459	0.633	86.62	303.2	13,392	126
Beta 4490R	41.52	18.60	15,436	0.662	86.43	321.5	13,340	85
Beta 4773R	39.51	18.53	14,654	0.649	86.59	321.0	12,691	112
Beta 4614R	41.92	17.15	14,374	0.611	86.83	297.8	12,481	110
Hilleshog/Syngenta								
HM 1642	42.24	18.81	15,887	0.578	87.55	329.3	13,908	111
HM Owyhee	43.73	18.19	15,910	0.613	87.00	316.6	13,842	113
HM 2989Rz	43.32	18.43	15,962	0.661	86.42	318.6	13,794	149
HM PM21	42.88	18.29	15,680	0.579	87.45	319.9	13,711	110
HM 2986Rz	42.13	18.46	15,550	0.597	87.25	322.2	13,569	104
HM Alliance	42.07	18.26	15,365	0.554	87.76	320.5	13,486	108
HM Oasis	42.68	17.93	15,316	0.593	87.21	312.8	13,359	123
HM 2980Rz	42.59	18.00	15,310	0.678	86.12	310.1	13,183	131
HM 2984Rz	42.73	17.77	15,192	0.630	86.70	308.2	13,173	141
HM 2988Rz	40.56	18.24	14,798	0.562	87.66	319.7	12,971	144
Holly Hybrids								
Acclaim R	48.63	17.13	16,662	0.727	85.32	292.4	14,217	146
Phoenix R	47.30	17.11	16,174	0.678	85.96	294.1	13,900	138
Meridian R	46.49	17.28	16,063	0.676	86.02	297.3	13,817	162
Eagle R	45.93	17.18	15,763	0.704	85.62	294.1	13,497	123
HH 142 R	42.53	17.28	14,681	0.708	85.59	295.8	12,567	151
Seedex								
SX Cascade	45.69	17.71	16,178	0.550	87.72	310.8	14,192	101
SX Puma	41.40	18.04	14,932	0.588	87.29	315.0	13,032	123
SX Raptor Rz	42.04	17.77	14,927	0.665	86.25	306.5	12,873	150
Mean	42.98	17.95	15,412	0.640	86.60	311.0	13,345	122
LSD (0.05)	2.51	0.50	914	0.040	0.55	9.6	792	43
LSD (0.10)	2.11	0.42	766	0.034	0.46	8.1	664	36
CV (%)	5.9	2.8	6.0	6.3	0.6	3.1	6.0	35.6

Table 3. Experimental sugar beet variety root yield, sugar content, root quality, recoverable sugar, and nitrate content from varieties entered in the trial at Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

	Root yield	Sugar content	Gross sugar	Conduc-tivity	Extrac-tion	Estimated recoverable sugar		Nitrate content
Variety	ton/acre	%	lb/acre	mmho	%	lb/ton	lb/acre	ppm
ACH Seeds								
Crystal 316R	45.29	17.39	15,720	0.710	85.59	297.7	13,450	168
Crystal 318R	43.00	17.61	15,144	0.513	88.17	310.5	13,354	144
Crystal 411R	44.28	17.44	15,443	0.768	84.85	296.0	13,101	166
Crystal 412R	42.71	17.50	14,951	0.759	84.96	297.4	12,705	170
Crystal 217R	41.28	17.48	14,440	0.721	85.46	298.8	12,344	233
Betaseed								
Beta 4YK0024	45.03	17.79	16,021	0.693	85.89	305.6	13,760	126
Beta 2YK0016	45.61	17.55	15,993	0.751	85.09	298.8	13,607	223
Beta 4YK0023	42.19	18.37	15,467	0.656	86.46	317.7	13,367	137
Beta 3YK0019	43.72	17.78	15,532	0.706	85.71	304.8	13,312	177
Beta 4490R	42.59	18.06	15,377	0.714	85.65	309.4	13,170	163
Beta 4YK0025	42.19	17.94	15,129	0.681	86.08	308.9	13,021	158
Beta 3YK0020	43.67	17.13	14,958	0.711	85.53	293.1	12,793	170
Hilleshog/Syngenta								
HM PM90	44.48	18.38	16,354	0.616	87.00	319.9	14,228	190
HM 2993Rz	47.33	17.25	16,328	0.728	85.33	294.5	13,933	219
HM 2995Rz	44.86	17.68	15,846	0.657	86.34	305.2	13,680	176
HM 2992Rz	44.71	17.64	15,773	0.680	86.03	303.5	13,572	176
HM 2986Rz	42.87	17.90	15,342	0.646	86.52	309.8	13,274	149
HM 2991Rz	40.99	18.22	14,931	0.547	87.85	320.2	13,116	138
HM 2994Rz	39.69	17.88	14,199	0.715	85.61	306.2	12,157	189
Holly Hybrids								
04HX422 R	49.51	16.46	16,286	0.706	85.46	281.4	13,920	209
04HX438 R	48.02	16.68	16,017	0.688	85.74	286.1	13,733	191
04HX437 R	45.70	17.11	15,627	0.759	84.90	290.5	13,266	250
04HX434 R	43.06	17.70	15,245	0.613	86.92	307.7	13,251	201
04HX436 R	44.39	17.26	15,316	0.733	85.26	294.4	13,061	217
03HX353 R	40.12	17.93	14,384	0.602	87.10	312.3	12,528	141
04HX431 R	38.44	17.43	13,385	0.649	86.39	301.1	11,561	205
Seedex								
SX Raptor Rz	43.03	17.43	14,992	0.697	85.77	299.1	12,853	206
SX1522	39.54	18.37	14,526	0.634	86.76	318.8	12,601	172
SX1521	39.71	18.15	14,408	0.663	86.34	313.5	12,441	187
Mean	43.37	17.64	15,280	0.680	86.03	303.6	13,144	181
LSD (0.05)	2.50	0.45	886	0.048	0.67	9.3	763	51
LSD (0.10)	2.10	0.38	742	0.040	0.56	7.8	639	43
CV (%)	5.8	2.6	5.8	7.0	0.8	3.1	5.8	28.4

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

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Ontario, OR, 2004

Introduction

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

Methods

This trial was established at the Malheur Experiment Station under furrow irrigation on April 8, 2004. Sugar beets (Hilleshog 'PM-21') were planted in 22-inch rows at a 2-inch seed spacing. On April 9, the trial was corrugated and Counter 20 CR® was applied in a 7-inch band over the row at 6 oz/1,000 ft of row. Sugar beets were thinned to 8-inch spacing on May 10 to 13. Plots were sidedressed on June 2 with 175 lb nitrogen (urea), 30 lb potash (K_2O), 35 lb sulfates (SO_4), 38 lb elemental sulfur (S), 3 lb manganese (Mn), 2 lb zinc (Zn), and 1 lb/acre boron (B). All plots were treated with Roundup® (0.75 lb ai/acre) on April 13 prior to sugar beet emergence. On May 26, Temik 15G® (14 lb prod/acre) was applied for sugar beet root maggot control. For powdery mildew control, Headline® (12 fl oz/acre) was applied on June 25, Topsin M® (20 oz prod/acre) plus S at 6 lb/acre, phosphate (P_2O_5) at 1.5 lb/acre, and Zn at 0.2 lb/acre were applied August 4, and Headline (12 fl oz/acre) plus S at 6 lb/acre were applied August 8. All fungicide treatments were applied by air. Herbicide treatments were broadcast-applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were 4 rows wide and 27 ft long and treatments were arranged in a randomized complete block design with 4 replicates.

The treatments in this trial consisted of both standard and micro-rate postemergence weed control programs applied with or without a preemergence application of Nortron at either 16, 24, or 32 oz ai/acre with and without postemergence UpBeet. For the micro-rate treatment without UpBeet, Nortron was also applied preemergence at 48 oz ai/acre. UpBeet was omitted from selected treatments to simulate ALS resistance and to better evaluate preemergence Nortron efficacy on kochia. Nortron was applied preemergence on April 13. The standard rate program included three applications, with the first applied to full cotyledon sugar beets on April 26, the second to two- to four-leaf sugar beets on May 3, and the third application to six- to eight-leaf sugar beets on May 14. Progress (ethofumesate + phenmedipham + desmedipham) was applied at 4.0, 5.4, and 6.7 oz ai/acre in the first, second, and third applications, respectively. UpBeet was applied at 0.25 oz ai/acre in all three applications (excluding treatments where UpBeet was omitted). Stinger® (clopyralid) was applied in the second and third applications at 1.5 oz ai/acre. The micro-rate program consisted of four applications with the first applied to cotyledon sugar beets on April 23, the second to cotyledon to 2-leaf sugar beets on April 30, the third application was inadvertently delayed and was applied to 8- to 10-leaf sugar beets on May 15, and the fourth to 8- to 12-leaf sugar beets on May 20. In the micro-rate program, Progress® was applied at 1.3 oz ai/acre in the first two applications and at 2.0 oz ai/acre in the last two applications. All four micro-rate applications included UpBeet at 0.08 oz ai/acre (excluding treatments where UpBeet was omitted), Stinger at 0.5 oz ai/acre, and a methylated seed oil (MSO) at 1.5 percent v/v.

Sugar beet injury was evaluated May 10 and June 9 and weed control was evaluated September 3. Sugar beet yields were determined by harvesting the center two rows of each plot on October 8 and 9. Root yields were adjusted to account for a 5 percent tare. One sample of 16 beets was taken from each plot for quality analysis. The samples were coded and sent to Syngenta Seeds Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity. Sucrose content and recoverable sucrose were estimated using empirical equations. Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval (P = 0.05). The untreated control was not included in the analysis of variance for weed control or crop response.

Results and Discussion

Postemergence herbicides were very effective this year. Kochia control was greater than 98 percent with either the standard rate or micro-rate treatments containing UpBeet regardless of whether preemergence Nortron was applied (Table 1). Removing UpBeet from the standard rate and the micro-rate resulted in a respective 18 and 58 percent decrease in kochia control on July 17. For the standard rate treatments without UpBeet, the addition of Nortron at any rate provided kochia control similar to the standard rate with UpBeet. For micro-rate treatments without UpBeet, the addition of preemergence Nortron, regardless of the rate, did not control kochia as well as the micro-rate with UpBeet. Increasing Nortron rates increased kochia control. Pigweed control also was reduced when UpBeet was omitted from the micro-rate. The addition of Nortron at 16 or 24 oz ai/acre improved kochia control, but the 32- or 48- oz ai/acre rates were required to control kochia equal to the micro-rate with UpBeet. There were no differences among treatments for common lambsquarters, hairy nightshade, or barnyardgrass control. Common lambsquarters and hairy nightshade control was 98 percent or higher while barnyardgrass control ranged from 87 to 99 percent.

Injury on May 10 was significantly higher for standard rate treatments with UpBeet compared to standard rate treatments without UpBeet or compared to any of the micro-rate treatments (Table 2). Within the micro-rate treatments, the 48- oz ai/acre rate of Nortron caused greater injury (23 vs 5-14 percent) than any of the other micro-rate treatments with or without Nortron preemergence. On June 9, injury was similar among all treatments. Sugar beet yields were not significantly different among any of the standard rate treatments. Sugar beet yields were lowest with the micro-rate applied without UpBeet. The addition of preemergence Nortron at 32 oz ai/acre to the micro-rate without UpBeet was the only treatment that produced yields similar to the micro-rate with UpBeet. The lower Nortron rates had lower yields and the 48- oz ai/acre Nortron treatment also yielded less than the micro-rate with UpBeet. The lower yield with the high rate of Nortron may have been related to the increased sugar beet injury.

In areas where kochia has become resistant to UpBeet, a preemergence application of Nortron followed by postemergence herbicides at standard rates should provide effective control. Removing UpBeet from the spray mixture may not be advisable since UpBeet would still be effective in controlling non-UpBeet-resistant kochia and also helps control other weeds. The micro-rate should not be used in areas with UpBeet resistant kochia because even with high rates of preemergence Nortron, acceptable kochia control cannot be achieved.

Table 1. Kochia control with preemergence Nortron® in standard and micro-rate herbicide programs, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

			Weed control					
			Kochia		Pigweed[‡] spp.	Lambs-quarters	Hairy nightshade	Barnyard-grass
Treatment*	Rate	Timing[†]	7-27	9-3	7-27	7-27	7-27	7-27
	oz ai/acre & % v/v		%					
Untreated control	--	--	--	--	--	--	--	--
Standard Rate Program								
Progress + UpBeet	4.0 + 0.25	3	100	100	100	100	99	95
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	5						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	6						
Micro-Rate Program								
Progress + UpBeet + Stinger + MSO	1.3 + 0.083 + 0.5 + 1.5% v/v	2,4	98	98	97	100	100	97
Progress + UpBeet + Stinger + MSO	2.0 + 0.083 + 0.5 + 1.5% v/v	7,8						
Nortron fb	16.0	1	100	100	99	100	100	97
Standard with Upbeet	---	3,5,6						
Nortron fb	24.0	1	100	100	100	100	100	98
Standard with UpBeet	---	3,5,6						
Nortron fb	32.0	1	100	100	100	100	100	99
Standard with UpBeet	---	3,5,6						
Nortron fb	16.0	1	100	100	100	100	100	93
Standard w/out UpBeet	---	3,5,6						
Nortron fb	24.0	1	94	96	98	100	100	93
Standard w/out UpBeet	---	3,5,6						
Nortron fb	32.0	1	98	98	100	100	100	97
Standard w/out UpBeet	---	3,5,6						
Nortron fb	16.0	1	100	100	100	99	100	91
Micro with UpBeet	---	2,4,7,8						
Nortron fb	24.0	1	99	99	100	100	100	97
Micro with UpBeet	---	2,4,7,8						
Nortron fb	32.0	1	100	100	100	100	100	95
Micro with UpBeet	---							
Nortron fb	16.0	1	62	58	91	100	100	93
Micro w/out UpBeet	---	2,4,7,8						
Nortron fb	24.0	1	66	65	91	100	100	92
Micro w/out UpBeet	---	2,4,7,8						
Nortron fb	32.0	1	75	73	98	100	100	92
Micro w/out UpBeet	---	2,4,7,8						
Standard w/out UpBeet	---	3,5,6	82	88	95	100	100	95
Micro w/out UpBeet	---	2,4,7,8	40	48	80	100	100	87
Nortron fb	48.0	1	84	86	98	98	100	97
Micro w/out UpBeet	---	2,4,7,8						
LSD (0.05)	--		8	8	6	NS	NS	NS

*fb = Followed by.

[†]Application timings were (1) April 13 preemergence, (2) April 23 to cotyledon beets, (3) April 26 to full cotyledon beets, (4) April 30 to 2-leaf beets, (5) May 3 to 2- to 4-leaf beets, (6) May 14 to 6- to 8-leaf beets, (7) May 15 to 8- to 10-leaf beets, and (8) May 20 to 8- to 12-leaf beets.

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

Table 2. Sugar beet injury and yield with preemergence Nortron® in standard and micro-rate herbicide programs, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

			Sugar beet					
			Injury		Yield[‡]			
Treatment*	Rate	Timing[†]	5-10	6-9	Root yield	Sucrose	Extraction	ERS[§]
	oz ai/acre and % v/v		------- % -------		ton/acre	------------ % ------------		lbs/acre
Untreated control	--	--	--	--	6.1	16.6	93.5	1,958
Standard Rate Program								
Progress + UpBeet	4.0 + 0.25	3	33	21	41.1	16.7	93.6	12,802
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	5						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	6						
Micro-Rate Program								
Progress + UpBeet + Stinger + MSO	1.3 + 0.083 + 0.5 + 1.5% v/v	2,4	9	9	44.3	16.5	93.0	13,614
Progress + UpBeet + Stinger + MSO	2.0 + 0.083 + 0.5 + 1.5% v/v	7,8						
Nortron fb	16.0	1	30	18	42.7	17.1	93.4	13,616
Standard with UpBeet	---	3,5,6						
Nortron fb	24.0	1	30	15	39.8	17.1	93.2	12,653
Standard with UpBeet	---	3,5,6						
Nortron fb	32.0	1	32	20	40.9	16.9	93.3	12,940
Standard with UpBeet	---	3,5,6						
Nortron fb	16.0	1	13	11	40.6	16.9	93.1	12,770
Standard w/out UpBeet	---	3,5,6						
Nortron fb	24.0	1	15	21	39.6	16.4	93.0	12,067
Standard w/out UpBeet	---	3,5,6						
Nortron fb	32.0	1	18	14	42.1	16.1	93.9	12,613
Standard w/out UpBeet	---	3,5,6						
Nortron fb	16.0	1	11	18	42.2	16.5	93.7	13,025
Micro with UpBeet	---	2,4,7,8						
Nortron fb	24.0	1	10	11	42.2	16.3	93.1	12,792
Micro with UpBeet	---	2,4,7,8						
Nortron fb	32.0	1	13	14	40.5	17.1	93.5	12,918
Micro with UpBeet	---							
Nortron fb	16.0	1	11	18	29.4	17.4	93.3	9,509
Micro w/out UpBeet	---	2,4,7,8						
Nortron fb	24.0	1	14	15	34.5	17.6	93.6	11,386
Micro w/out UpBeet	---	2,4,7,8						
Nortron fb	32.0	1	5	13	38.0	17.3	93.5	12,300
Micro w/out UpBeet	---	2,4,7,8						
Standard w/out UpBeet	---	3,5,6	19	13	38.8	17.0	93.4	12,345
Micro w/out UpBeet	---	2,4,7,8	6	6	29.3	17.7	93.9	9,786
Nortron fb	48.0	1	23	26	35.2	17.5	93.4	11,490
Micro w/out UpBeet	---	2,4,7,8						
LSD (0.05)	--		8	13	6.1	0.8	NS	1,937

*fb = Followed by

[†]Application timings were (1) April 13 preemergence, (2) April 23 to cotyledon beets, (3) April 26 to full cotyledon beets, (4) April 30 to 2-leaf beets, (5) May 3 to 2 to 4-leaf beets, (6) May 14 to 6 to 8-leaf beets, (7) May 15 to 8 to 10-leaf beets, and (8) May 20 to 8 to 12-leaf beets.

[‡]Sugar beets were harvested October 8 and 9.

[§]ERS = estimated recoverable sucrose.

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

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Introduction

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

Methods

This trial was established at the Malheur Experiment Station under furrow irrigation on April 8, 2004. Sugar beets (Hilleshog 'PM-21') were planted in 22-inch rows at a 2-inch seed spacing. On April 9, the trial was corrugated and Counter 20 CR® was applied in a 7-inch band over the row at 6 oz/1,000 ft of row. Sugar beets were thinned to 8-inch spacing on May 10 to 13. Plots were sidedressed on June 2 with 175 lb nitrogen (N) (urea), 30 lb potash (K_2O), 35 lb sulfates (SO_4), 38 lb elemental sulfur (S), 3 lb manganese (Mn), 2 lb zinc (Zn), and 1 lb/acre boron (B). All plots were treated with Roundup® (0.75 lb ai/acre) on April 13 prior to sugar beet emergence. On May 26, Temik 15G® (14 lb prod/acre) was applied for sugar beet root maggot control. For powdery mildew control, Headline® (12 fl oz/acre) was applied on June 25, Topsin M® (20 oz prod/acre) plus S at 6 lb/acre, phosphate (P_2O_5) at 1.5 lb/acre, and Zn at 0.2 lb/acre were applied on August 4, and Headline (12 fl oz/acre) plus S at 6 lb/acre were applied on August 8. All fungicide treatments were applied by air. Herbicide treatments were broadcast applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were 4 rows wide and 27 ft long and treatments were arranged in a randomized complete block design with 4 replicates.

Outlook, Dual Magnum, and Treflan® were applied at various timings as part of a standard rate herbicide program to evaluate the effect of application timing on weed control and crop response. The standard rate program consisted of Progress® applied at 4.0, 5.4, and 6.7 oz ai/acre in the first, second, and third applications, respectively. UpBeet® was applied at 0.25 oz ai/acre in all three applications and Stinger® at 1.5 oz ai/acre in the last two applications. Dual Magnum was applied preemergence only, or in the second or third postemergence application, or preemergence and in the second application, or in the second and third applications. Outlook was applied in the second or third applications. Both Dual Magnum and Outlook were applied in combination with Treflan in the second postemergence application. The preemergence treatments were applied April 13. The first, second, and third postemergence applications were made on April 26, May 3, and May 14, to cotyledon, 2- to 4-leaf, and 6- to 10-leaf beets, respectively.

Sugar beet injury was evaluated on May 10 and June 9 and weed control was evaluated on September 3. Sugar beet yields were determined by harvesting the center two rows of each plot on October 8 and 9. Root yields were adjusted to account for a 5 percent tare. One sample of 16 beets was taken from each plot for quality analysis. The samples were coded and sent to Syngenta Seeds Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity. Sucrose content and recoverable sucrose were estimated using empirical equations. Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval ($P = 0.05$). The untreated control was not included in the analysis of variance for weed control or crop response.

Results and Discussion

The addition of Outlook or Dual Magnum or combinations of Outlook or Dual Magnum with Treflan improved barnyardgrass control compared to the standard postemergence treatment alone (Table 1). For all other weeds, control was similar among treatments. There also were no differences in sugar beet injury (Table 2) or sugar beet stand (data not shown) among treatments. All herbicide treatments had greater yields compared to the untreated control, but yields did not differ among herbicide treatments.

This research suggests that both Dual Magnum and Outlook can be applied in combination with standard rate herbicides in sugar beets without significant sugar beet injury. No injury was observed with preemergence applications of Dual Magnum in this trial. However, in other sugar beet production regions, under extremely wet conditions, Dual Magnum has caused sugar beet injury when applied preemergence. In 2004, weather conditions were favorable and maximized the weed control provided by postemergence herbicide treatments. Under different environmental conditions, Dual Magnum or Outlook may have provided increased levels of broadleaf weed control. Besides helping control annual weeds, both Dual Magnum and Outlook are effective in suppressing yellow nutsedge in sugar beet.

Table 1. Weed control in sugar beet with standard rate herbicide treatments including postemergence applications of Outlook® and Dual Magnum®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment	Rate	Timing*	Weed control[†]				
			Kochia	Pigweed Spp.	Lambs-quarters	Hairy nghtshade	Barnyard-grass
	oz ai/acre		---------	---------	%	---------	---------
Untreated control	--	--	--	--	--	--	--
Progress + UpBeet + Dual Magnum	4.0 + 0.25 + 15.3	1	100	100	100	100	100
Progress + UpBeet + Stinger + Dual Magnum	5.4 + 0.25 + 1.5 + 15.3	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Progress + UpBeet	4.0 + 0.25	1	100	100	100	100	97
Progress + UpBeet + Stinger + Dual Magnum	5.4 + 0.25 + 1.5 + 15.3	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Progress + UpBeet	4.0 + 0.25	1	100	100	100	100	100
Progress + UpBeet + Stinger + Dual Magnum	5.4 + 0.25 + 1.5 + 15.3	2					
Progress + UpBeet + Stinger + Dual Magnum	6.7 + 0.25 + 1.5 + 15.3	3					
Dual Magnum	20.3	PRE	100	100	100	100	100
Progress + UpBeet	4.0 + 0.25	1					
Progress + UpBeet + Stinger + Dual Magnum	5.4 + 0.25 + 1.5 + 15.3	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Progress + UpBeet	4.0 + 0.25	1	99	100	100	100	84
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Dual Magnum	20.3	PRE	100	100	100	100	100
Progress + UpBeet	4.0 + 0.25	1					
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Progress + UpBeet	4.0 + 0.25	1	100	100	100	100	98
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2					
Progress + UpBeet + Stinger + Dual Magnum	6.7 + 0.25 + 1.5 + 15.3	3					
Progress + UpBeet	4.0 + 0.25	1	100	100	100	100	100
Progress + UpBeet + Stinger + Outlook	5.4 + 0.25 + 1.5 + 13.4	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Progress + UpBeet	4.0 + 0.25	1	100	100	100	100	100
Progress + UpBeet + Stinger + Outlook + Treflan	5.4 + 0.25 + 1.5 + 13.4 + 8.0	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
Progress + UpBeet	4.0 + 0.25	1	100	100	100	100	98
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2					
Progress + UpBeet + Stinger + Outlook	6.7 + 0.25 + 1.5 + 13.4	3					
Progress + UpBeet	4.0 + 0.25	1	100	100	100	100	98
Progrees + UpBeet + Stinger + Dual Magnum + Treflan	5.4 + 0.25 + 1.5 + 15.3 + 8.0	2					
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3					
LSD (0.05)	--	--	NS	NS	NS	NS	6

*Application timings were (PRE) April 13, (1) April 26 to cotyledon beets, (2) May 3 to 2- to 4-leaf beets, and (3) May 14 to 6- to 10-leaf beets.

[†]Weed control was evaluated October 8 and 9. Pigweed species included Powell amaranth and redroot pigweed.

Table 2. Sugar beet injury and yield with standard rate herbicide treatments including postemergence applications of Outlook® and Dual Magnum®, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

			Sugar beet					
			Injury		Yield†			
Treatment	Rate	Timing*	5-10	6-9	Root yield	Sucrose	Extraction	ERS
	oz ai/acre		------ % -----		ton/acre	---------- % ----------		lbs/acre
Untreated control	--	--	--	--	11.9	17.4	93.4	3,901
Progress + UpBeet + Dual Magnum	4.0 + 0.25 + 15.3	1	24	9	46.0	17.5	93.6	15,019
Progress + UpBeet + Stinger + Dual Magnum	5.4 + 0.25 + 1.5 + 15.3	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Progress + UpBeet	4.0 + 0.25	1	27	13	43.0	16.8	93.4	13,594
Progress + UpBeet + Stinger + Dual Magnum	5.4 + 0.25 + 1.5 + 15.3	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Progress + UpBeet	4.0 + 0.25	1	21	20	44.1	17.0	93.4	14,053
Progress + UpBeet + Stinger + Dual Magnum	5.4 + 0.25 + 1.5 + 15.3	2						
Progress + UpBeet + Stinger + Dual Magnum	6.7 + 0.25 + 1.5 + 15.3	3						
Dual Magnum	20.3	PRE	35	20	41.8	17.3	93.7	13,506
Progress + UpBeet	4.0 + 0.25	1						
Progress + UpBeet + Stinger + Dual Magnum	5.4 + 0.25 + 1.5 + 15.3	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Progress + UpBeet	4.0 + 0.25	1	25	11	44.3	17.8	93.7	14,717
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Dual Magnum	20.3	PRE	31	16	42.1	17.2	93.4	13,552
Progress + UpBeet	4.0 + 0.25	1						
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Progress + UpBeet	4.0 + 0.25	1	27	13	44.4	17.1	93.4	14,191
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2						
Progress + UpBeet + Stinger + Dual Magnum	6.7 + 0.25 + 1.5 + 15.3	3						
Progress + UpBeet	4.0 + 0.25	1	30	24	43.0	17.3	94.5	13,902
Progress + UpBeet + Stinger + Outlook	5.4 + 0.25 + 1.5 + 13.4	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Progress + UpBeet	4.0 + 0.25	1	29	10	43.8	17.3	93.6	14,187
Progress + UpBeet + Stinger + Outlook + Treflan	5.4 + 0.25 + 1.5 + 13.4 + 8.0	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
Progress + UpBeet	4.0 + 0.25	1	30	15	40.9	17.1	93.5	13,063
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5	2						
Progress + UpBeet + Stinger + Outlook	6.7 + 0.25 + 1.5 + 13.4	3						
Progress + UpBeet	4.0 + 0.25	1	24	10	45.2	17.6	93.7	14,917
Progrees + UpBeet + Stinger + Dual Magnum + Treflan	5.4 + 0.25 + 1.5 + 15.3 + 8.0	2						
Progress + UpBeet + Stinger	6.7 + 0.25 + 1.5	3						
LSD (0.05)	--		NS	NS	6.6	NS	NS	2,283

*Application timings were (PRE) April 13, (1) April 26 to cotyledon beets, (2) May 3 to 2- to 4-leaf beets, and (3) May 14 to 6- to 10-leaf beets.

†Sugar beets were harvested on October 8 and 9. ERS = estimated recoverable sucrose.

COMPARISON OF CALENDAR DAYS AND GROWING DEGREE-DAYS FOR SCHEDULING HERBICIDE APPLICATIONS IN SUGAR BEET

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Introduction

Timely herbicide application is critical to achieve effective weed control in sugar beet. Often, the amount of time between sequential herbicide applications is based on a given number of calendar days since the prior herbicide application. Under most circumstances this approach works well. When spring weather is cooler than normal, applying herbicides on a calendar day schedule may result in applications too close together. This can result in greater injury to the beets or herbicides being applied before they are needed. Since weed and beet growth depend on temperature, it is logical that using accumulated growing degree-days (GDD) to schedule herbicide applications may be superior to calendar days. GDD accounts for variations in the weather and gives a more accurate idea of how fast plants are growing. If the weather is ideal for weed and beet growth, herbicide applications are made closer together; if the weather is cool, then applications are spaced further apart. Evaluation of a GDD model for timing herbicide applications may provide producers with a tool to improve the efficacy of the herbicides they are using.

Methods

A trial was established at the Malheur Experiment Station under furrow irrigation on April 8, 2004. Sugar beets (Hilleshog 'PM-21') were planted in 22-inch rows at 2-inch seed spacing. On April 9, 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 an 8-inch spacing on May 10 to 13. Plots were sidedressed on June 2 with 175 lb nitrogen (N) (urea), 30 lb potash (K_2O), 35 lb sulfates (SO_4), 38 lb elemental sulfur (S), 3 lb manganese (Mn), 2 lb zinc (Zn), and 1 lb/acre boron (B). All plots were treated with Roundup® (0.75 lb ai/acre) on April 13 prior to sugar beet emergence. On May 26, Temik 15G® (14 lb prod/acre) was applied for sugar beet root maggot control. Poast® at 16 oz/acre plus crop oil concentrate at 1 qt/acre were applied to the trial area on June 16. For powdery mildew control, Headline® (12 fl oz/acre) was applied on June 25, Topsin M® (20 oz prod/acre) plus S at 6 lb/acre, phosphate (P_2O_5) at 1.5 lb/acre, and Zn at 0.2 lb/acre were applied on August 4, and Headline® (12 fl oz/acre) plus S at 6 lb/acre were applied on August 8. All fungicide treatments were applied by air. Herbicide treatments were broadcast applied with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Plots were 4 rows wide and 27 ft long and treatments were arranged in a randomized complete block design with 4 replicates.

Standard rate, increased standard rate, and micro-rate treatments were compared when applied on fixed calendar day schedules or when applied on different GDD accumulation schedules. The standard and high-standard-rate treatments were applied every 7 or 10 days and these timings were compared to applications at 150, 175, or 225 accumulated GDD since the previous application. The micro-rate treatments were applied on a 5- or 7-day schedule or at 150, 175, or 225 GDD since the previous application. Growing degree-days were calculated on a base of 34°F using the equation GDD = [(daily high temperature – daily low temperature)/2] – 34. GDD were calculated beginning the day after each herbicide application. Herbicide application dates and GDD measured between applications are shown in Table 1.

Table 1. Application dates for herbicide treatments applied to sugar beet on calendar day or growing degree-day (GDD) schedules, Malheur Experiment Station, Ontario, OR, 2004.

		Application				
Treatment*	Timing†	PRE	1st	2nd	3rd	4th
		Calendar date (GDD since previous application)				
Standard/High Rate	7 Day	4/13	4/26	5/3	5/10	--
Standard/High Rate	10 Day	4/13	4/26	5/6	5/16	--
Standard/High Rate	150 GDD	4/13	4/26	5/3 (151)	5/10 (199)	--
Standard/ High Rate	175 GDD	4/13	4/26	5/4 (187)	5/12 (173)	--
Standard/High Rate	225 GDD	4/13	4/26	5/6 (252)	5/17 (228)	--
Micro-rate	5 Day	4/13	4/23	4/29	5/4	5/9
Micro-rate	7 Day	4/13	4/23	5/1	5/8	5/15
Micro-rate	150 GDD	4/13	4/23	5/1 (152)	5/7 (164)	5/15 (153)
Micro-rate	175 GDD	4/13	4/23	5/2 (180)	5/9 (206)	5/22 (201)
Micro-rate	225 GDD	4/13	4/23	5/4 (249)	5/12 (220)	5/26 (228)

*Standard and high-standard-rate treatments were applied on the same dates.
†Application timing based on GDD were determined by calculating the number of GDD beginning the day after the previous application, using the equation GDD = [(daily high temperature – daily low temperature)/2] – 34.

Sugar beet injury was evaluated on May 29 and June 9, and weed control was evaluated on September 3. Sugar beet yields were determined by harvesting the center two rows of each plot on October 8 and 9. Root yields were adjusted to account for a 5 percent tare. One sample of 16 beets was taken from each plot for quality analysis. The samples were coded and sent to Syngenta Seeds Research Station in Nyssa, Oregon, to determine beet pulp sucrose content and purity. Sucrose content and recoverable sucrose were estimated using empirical equations. Data were analyzed using analysis of variance procedures and means were separated using protected LSD at the 95 percent confidence interval (P = 0.05). The untreated control was not included in the analysis of variance for weed control or crop response.

Results and Discussion

For the standard and high-rate herbicide treatments, the number of days between herbicide applications was the same for the 7-day schedule and the 150-GDD schedule. Applications on the 10-day schedule were within a day of the applications based on 225 GDD. The 175-GDD-spray schedule was between the other schedules. The final application of the standard and high rate herbicide treatments varied by as much as 7 days between application schedules. For micro-rate treatments, the 5-day application schedule was shorter than all other application schedules with the final application made by May 9. The 7-day application timing was almost the same as the timing based on 150-GDD. Applications based on 175 GDD were generally 1 to 7 days later than the 150-GDD schedule and applications with the 225-GDD schedule were likewise delayed 2 to 4 days compared to 175 GDD. The final application date among the different application schedules varied by as much as 17 days. In different years, the GDD application schedules could be significantly different from the fixed day application timings, depending on the weather patterns.

Postemergence treatments were very effective this year and timing had little effect on weed control. Pigweed and common lambsquarters control were reduced when the micro-rate was applied on a 225-GDD interval compared to all other treatments (Table 2). All other treatments and timings provided 94 percent or higher control of pigweed, common lambsquarters, hairy nightshade, kochia, and barnyardgrass. It is surprising that such a wide range of application timings could produce such complete control of all species. Since the standard rate was so effective, no differences were observed between the standard rate and the high-standard-rate treatments.

On May 24, injury from the standard or high-standard-rate treatments was among the greatest with the 175-GDD-application timing (Table 3). This does not appear to be related to the interval between herbicide applications, but seems to be related to rainfall events preceding those herbicide applications. There was no difference in sugar beet injury among the micro-rate treatments. By June 9, there were no differences in sugar beet injury between any of the herbicide treatments or application timings.

All herbicide treatments increased sugar beet root yield and estimated recoverable sugar compared to the untreated check (Table 3). There were no differences in percent extraction or sugar content for any treatment. Root yields were not different among the herbicide treatments and application timings. The high rate applied on a 10-day interval produced more estimated recoverable sucrose than the standard rate applied on the same 10-day schedule or the micro-rate applied on the 225-GDD-application schedule.

This year application timing was not critical because the postemergence treatments worked very well. In addition, the initial postemergence applications were made at the correct time while weeds were small. If the initial timing is delayed, the time between subsequent applications may be much more critical.

Table 2. Weed control in sugar beet with standard rate, high-standard-rate, and micro-rate herbicide treatments applied on a calendar day schedule or at different growing degree-day (GDD) intervals, Malheur Experiment Station, Ontario, OR, 2004.

Treatment*	Rate	Timing[†]	Weed control[‡] Pigweed spp.	Common lambsquarters	Hairy nightshade	Kochia	Barnyard-grass
	oz ai/acre or % v/v	--	%				
Standard Rate							
Progress + UpBeet	4.0 + 0.25	7 Day	99	100	100	100	96
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5						
Progress + UpBeet + Stinger	5.4 + 0.25 + 1.5						
Standard Rate	Same as above	10 Day	97	100	100	100	98
Standard Rate	Same as above	150 GDD	100	100	100	100	100
Standard Rate	Same as above	175 GDD	100	100	100	100	100
Standard Rate	Same as above	225 GDD	99	100	100	100	97
Micro-Rate							
Progress + UpBeet + Stinger + MSO	1.3 + 0.08 + 0.5 + 1.5% v/v	5 Day	96	99	100	99	98
Progress + UpBeet + Stinger + MSO	1.3 + 0.08 + 0.5 + 1.5% v/v						
Progress + UpBeet + Stinger + MSO	2.0 + 0.08 + 0.5 + 1.5% v/v						
Progress + UpBeet + Stinger + MSO	2.0 + 0.08 + 0.5 + 1.5% v/v						
Micro-Rate	Same as above	7 Day	96	100	100	100	100
Micro-Rate	Same as above	150 GDD	94	98	100	98	100
Micro-Rate	Same as above	175 GDD	98	99	100	100	100
Micro-Rate	Same as above	225 GDD	86	93	100	98	99
High Rate							
Progress + UpBeet	4.0 + 0.25	7 Day	100	100	100	100	98
Progress + UpBeet + Stinger	6.7 + 0.37 + 1.5						
Progress + UpBeet + Stinger	8.1 + 0.5 + 1.5						
High Rate	Same as above	10 Day	98	100	100	100	98
High Rate	Same as above	150 GDD	100	100	100	100	100
High Rate	Same as above	175 GDD	99	100	100	100	100
High Rate	Same as above	225 GDD	100	100	100	100	100
LSD (P = 0.05)	--	--	4	2	NS	NS	NS

*Standard and high-standard-rate treatments were applied on the same dates.
[†]Application timing based on GDD were determined by calculating the number of GDD beginning the day after the previous application using the equation GDD = [(daily high temperature – daily low temperature)/2] – 34.
[‡]Weed control was evaluated September 3. Pigweed species are a mixture of redroot pigweed and Powell amaranth.

Table 3. Sugar beet injury and yield with standard rate, high-standard-rate, and micro-rate herbicide treatments applied on a calendar day schedule or at different growing degree-day (GDD) intervals, Malheur Experiment Station, Ontario, OR, 2004.

			Sugar beet[‡]					
			Injury		Yield			
Treatment*	Rate	Timing[†]	5-24	6-9	Root yield	Extraction	Sucrose	ERS
--	oz ai/acre or % v/v	--	---- % ----		ton/acre	------------ % ------------		lbs/acre
Untreated control	--	--	--	--	6.6	93.7	17.0	2,119
Standard Rate Progress + UpBeet Progress + UpBeet + Stinger Progress + UpBeet + Stinger	 4.0 + 0.25 5.4 + 0.25 + 1.5 5.4 + 0.25 + 1.5	7 Day	14	11	45.2	93.1	16.6	14,001
Standard Rate	Same as above	10 Day	21	14	42.6	93.4	16.9	13,422
Standard Rate	Same as above	150 GDD	11	8	47.7	93.4	16.6	14,822
Standard Rate	Same as above	175 GDD	26	11	46.0	93.4	16.4	14,141
Standard Rate	Same as above	225 GDD	14	10	46.0	93.3	16.8	14,409
Micro-Rate Progress + UpBeet + Stinger + MSO Progress + UpBeet + Stinger + MSO Progress + UpBeet + Stinger + MSO Progress + UpBeet + Stinger + MSO	 1.3 + 0.08 + 0.5 + 1.5% v/v 1.3 + 0.08 + 0.5 + 1.5% v/v 2.0 + 0.08 + 0.5 + 1.5% v/v 2.0 + 0.08 + 0.5 + 1.5% v/v	5 Day	8	11	46.9	93.2	16.7	14,568
Micro-Rate	Same as above	7 Day	15	13	46.6	93.1	16.8	14,532
Micro-Rate	Same as above	150 GDD	17	11	45.6	93.1	16.7	14,195
Micro-Rate	Same as above	175 GDD	11	9	44.3	93.3	16.7	13,823
Micro-Rate	Same as above	225 GDD	9	10	42.5	93.4	16.9	13,398
High Rate Progress + UpBeet Progress + UpBeet + Stinger Progress + UpBeet + Stinger	 4.0 + 0.25 6.7 + 0.37 + 1.5 8.1 + 0.5 + 1.5	7 Day	19	6	47.3	93.4	16.3	14,396
High Rate	Same as above	10 Day	21	10	47.1	93.9	17.2	15,231
High Rate	Same as above	150 GDD	20	13	46.5	93.3	17.1	14,852
High Rate	Same as above	175 GDD	34	19	44.3	93.6	16.9	14,019
High Rate	Same as above	225 GDD	11	3	46.4	93.3	16.6	14,334
LSD (P = 0.05)	--		9	NS	4.4	NS	NS	1,459

*Standard and high standard rate treatments were applied on the same dates.
[†]Application timing based on GDD were determined by calculating the number of GDD beginning the day after the previous application using the equation GDD = [(daily high temperature – daily low temperature)/2] – 34.
[‡]Sugar beets were harvested October 8 and 9. ERS = estimated recoverable sucrose.

2004 WINTER ELITE WHEAT TRIAL

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Introduction

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

Methods

The previous crop was sweet corn. After harvest, the corn stalks were flailed, the field was disked, and the soil was sampled and analyzed. The analysis showed 138 lb nitrogen (N), 80 lb available phosphate (P_2O_5), 1,478 lb soluble potash (K_2O), and 70 lb sulfate (SO_4)/acre in the top 2 ft of soil, with 2,361 ppm calcium (Ca), 443 ppm magnesium (Mg), 107 ppm sodium (Na), 1.7 ppm zinc (Zn), 26 ppm iron (Fe), 7 ppm manganese (Mn), 0.6 ppm copper (Cu), 0.8 ppm boron (B), pH 7.6, and 3.2 percent organic matter in the top foot of soil. Pre-plant fertilizer was a broadcast application on October 7, 2003 of 97 lb N/acre, 5 lb Cu/acre, and 1 lb B/acre. The soil was deep ripped, plowed, and groundhogged to prepare the seedbed. The field was corrugated into 30-inch rows.

The Winter Elite Wheat Trial was comprised of 40 soft white winter wheat cultivars or lines, 3 of which were club head types. Seed of all entries was treated with fungicide and insecticide seed treatment prior to planting. Grain was planted at 30 live seed/ft^2, corresponding to a seeding rate of approximately 110 lb/acre. The experimental design was a randomized complete block with three replications. Grain was planted on October 17, 2003, with a small plot grain drill, into plots 5 by 20 ft, and then the field was recorrugated. The field was partially furrow irrigated on November 11 to promote emergence. The irrigation had to be stopped because the runoff water was interfering with irrigation district repairs.

A soil sample was taken from the field on April 2, 2004. The soil analysis showed ammonia and nitrate forms of N in the top 2 ft of soil totaled 86 lb N, with 38 lb extractable P_2O_5, 861 lb available K_2O, 83 lb SO_4/acre in the top 2 ft of soil, with 12 ppm Ca, 370 ppm Mg, 108 ppm Na, 1.2 ppm Zn, 2 ppm Fe, 1 ppm Mn, 0.5 ppm Cu, 1 ppm B, pH 7.7, and 3.2 percent organic matter. Urea prills fertilizer (95.6 lb N/acre) was broadcast over the trial on March 30, 2004. This application was an error. Broadleaf weeds were controlled with Bronate® at 1qt/acre applied on May 3. On May 20, fertilizer was broadcast to supply 13 lb N/acre, 60 lb P_2O_5/acre, 3 lb Zn/acre, and 1 lb Cu/acre. The field was furrow irrigated for 24 hours on April 9, May 5, and June 3. Observations of heading date were started on June 4, after 100 percent heading had already occurred in many varieties. Heading date observations should have started in May. Alleys 5 ft wide were cut with a Hege small plot combine on July 21. The length of each plot was measured and recorded after the alleys were cut, and the plots were harvested on July 21 with a Hege small plot combine.

Results

The grain plants in the Winter Elite Wheat Trial grew very lush, with lodging already observed on May 20, before heading. A thunderstorm brought 0.41 inch of rain and strong winds on May 18, followed by 0.89 more inches of rain in storms with wind over the following 10 days, contributing to the lodging that was observed. Plant height at maturity could not be measured in the trial this year because of extensive lodging. The residual nitrate plus ammonium in the fall of 2003 was substantial, and the trial received too much N fertilizer during its growth and development.

Among the soft white winter wheat varieties, the highest yielding was 'ORH010918' at 115 bushel/acre, which was not significantly (at LSD 0.05) higher than other entries in this trial (Table 1). Due to the heavy lodging observed, the trial is useful to compare variety resistance to lodging. ORH010918 was the only entry to show no lodging at harvest, suggesting that it may have exceptional straw strength, similar to 'ORCF-101', 'ORH011483', 'ORH010920', 'CODA', 'ORI2020015', 'OR9901887', 'MEL', 'SIMON', 'CLEARFIRST', and 'OR9900513', which were among the least severely lodged entries in this trial.

Table 1. Winter Elite Wheat Trial entries, market class, lodging, and yield, Malheur Experiment Station, Oregon State University, Ontario, OR, 2005.

Entry	Variety	Market class	Origin or developer	Lodging %	Yield* bushel†/acre
37	ORH010918	SWW	OSU	0	115.3
1	STEPHENS	SWW	OSU	57	114.3
31	OR9901887	SWW	OSU	43	113.2
25	OR9801757	SWW	OSU	97	107.4
23	OR3970965	SWW	OSU	90	106.6
40	ORH011483	SWW	OSU	17	106.3
39	ORH011481	SWW	OSU	60	105.9
10	DUNE	SWW	U of I	60	105.3
3	GENE	SWW	OSU	60	105.2
38	ORH010920	SWW	OSU	30	103.8
9	SIMON	SWW	U of I	47	102.4
36	OR2010353	SWW	OSU	100	99.5
19	ORCF-101	SWW-Clearfield	OSU	3	98.8
8	BRUNDAGE96	SWW	U of I	67	98.6
26	OR9900553	SWW	OSU	67	97.1
14	CODA	Club	ARS-WSU	37	96.6
33	OR2010239	SWW	OSU	67	95.7
35	OR2010242	SWW	OSU	90	95.0
7	ROD	SWW	WSU	97	94.6
21	ORI2020015	SWW-Clearfield	OSU	40	93.4
20	ORI2010007	SWW-Clearfield	OSU	67	93.2
18	IDO587CL	SWW-Clearfield	U of I	70	91.8
11	ID92-22407A	SWW	U of I	57	89.5
17	CLEARFIRST	SWW-Clearfield	Gen. Mills	50	89.3
34	OR2010241	SWW	OSU	83	88.5
28	OR9900598	SWW	OSU	90	88.0
4	WEATHERFORD	SWW	OSU	93	87.7
16	MEL	Club-Clearfield	Gen. Mills	43	87.2
6	FINCH	SWW	ARS-WSU	63	85.4
30	OR9900513	SWW	OSU	50	85.4
24	OR9801695	SWW	OSU	80	84.3
13	WESTBRD528	SWW	Westbred	90	83.2
2	MADSEN	SWW	ARS-WSU	80	80.8
32	OR9901619	SWW	OSU	90	80.1
5	TUBBS	SWW	OSU	97	78.2
29	OR9900547	SWW	OSU	93	75.1
15	CHUKAR	Club	ARS-WSU	57	74.5
12	MOHLER	SWW	Westbred	100	64.4
27	OR9900548	SWW	OSU	100	63.8
22	OR941611	SWW	OSU	70	63.2
	Mean			66.3	92.2
	LSD (0.05)			52.1	NS‡

*Adjusted to 10% moisture, †60 lb/bushel.
‡NS = Not Significant.

AUTOMATIC COLLECTION, RADIO TRANSMISSION, AND USE OF SOIL WATER DATA[1]

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Abstract

Precise scheduling of drip irrigation has become very important to help assure optimum drip-irrigated crop yield and quality. Soil moisture sensors have often been adopted to assure irrigation management. Integrated systems for using soil moisture data could enhance widespread applicability. An ideal system would include the equipment to monitor field conditions, radios to transmit the information from the field because wires impede cultivation and can complicate cultural practices, interpretation of soil water status, and the equipment to automatically control irrigation systems.
Key words: automation, irrigation scheduling, onion, *Allium cepa*

Introduction

Onions (*Allium cepa*) require frequent irrigations to maintain high soil moisture. Drip irrigation has become popular for onion production because a higher soil moisture can be maintained without the negative effects associated with furrow irrigation. Drip irrigation can also be automated. Automated drip irrigation of onions has been used for irrigation management research at the Malheur Experiment Station since 1995 (Feibert et al. 1996; Shock et al. 1996, 2002). However, the extensive wiring impedes cultivation and can complicate cultural practices. Several companies manufacture automated irrigation systems designed for commercial use that use radio telemetry, reducing the need for wiring. This trial tested three commercial soil moisture monitoring systems and compared their irrigation on onion performance to the research system based on Campbell Scientific (Logan, UT) components currently used (Shock et al. 2002).

Materials and Methods

The onions were grown at the Malheur Experiment Station (MES), Ontario, Oregon, on an Owyhee silt loam previously planted to wheat. Onion (cv. 'Vaquero', Nunhems, Parma, ID) was planted in 2 double rows, spaced 22 inches apart (center of double row to center of double row) on 44-inch beds on March 17, 2004. The 2 rows in the double row were spaced 3 inches apart. Onion was planted at 150,000 seeds/acre. Drip tape (T-tape, T-systems International, San Diego, CA) was laid at 4-inch depth between the 2

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1 This report is provided as a courtesy to onion growers. This work was supported by sources other than the Idaho-Eastern Oregon Onion Committee.

double onion rows at the same time as planting. The distance between the tape and the center of the double row was 11 inches. The drip tape had emitters spaced 12 inches apart and a flow rate of 0.22 gal/min/100 ft.

Onion emergence started on April 2. The trial was irrigated 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.

Weed and insect control practices were similar to typical crop production standards and fertilizer applications were similar to common practices and followed the recommendations of Sullivan et al. (2001).

The experimental design was a randomized complete block with three replicates. Each irrigation system was tested in 3 zones that were 16 rows by 50 ft long. There were four automated irrigation systems tested. Each integrated system contained several distinctive parts, some automated and some requiring human input: soil moisture monitoring, data transmission from the field, collection of the data, interpretation of the data, decisions to irrigate, and control of the irrigation. Additionally, all data were downloaded for evaluation of the system.

Campbell Scientific

The system currently used for research at MES uses a Campbell Scientific Inc. (Logan, UT) datalogger (CR10X). Each zone had four granular matrix sensors (GMS, Watermark Soil Moisture Sensor Model 200SS, Irrometer Co. Inc., Riverside, CA) used to measure soil water potential (SWP) (Shock 2003). The GMS from all three zones were connected to an AM416 multiplexer (Campbell Scientific), which in turn was connected to the datalogger at the field edge. The soil temperature was also monitored and was used to correct the SWP calibrations (Shock et al., 1998a). The datalogger was programmed to monitor the soil moisture and controlled the irrigations for each zone individually. The Campbell Scientific datalogger was programmed to make irrigation decisions every 12 hours: zones were irrigated for 8 hours if the SWP threshold was exceeded. The Campbell Scientific datalogger used an average soil water potential at 8-inch depth of -20 kPa or less as the irrigation threshold. The datalogger controlled the irrigations using an SDM16 controller (Campbell Scientific) to which the solenoid valves at each zone were connected. Data were downloaded from the datalogger with a laptop computer or with an SM192 Storage Module (Campbell Scientific) and a CR10KD keyboard display (Campbell Scientific). The datalogger was powered by a solar panel and the controller was powered by 24 V AC. The Campbell Scientific system was started on May 15, 2004.

Automata

Automata, Inc. (Nevada City, CA) manufactures dataloggers, controllers, and software for data acquisition and process control. Each one of the three zones had four GMS connected to a datalogger (Mini Field Station, Automata). The dataloggers at each zone were connected to a controller (Mini-P Field Station, Automata) at the field edge by an internal radio; The controllers were connected to a base station (Mini-P Base Station, Automata) in the office by radio. The base station was connected to a desktop computer. Each zone was irrigated individually using a solenoid valve. The solenoid valves were connected to and controlled by the controller. The desktop computer ran the software that monitored the soil moisture in each zone and made the irrigation decisions every 12 hours: zones were irrigated for 8 hours if the SWP threshold was exceeded. The irrigation threshold was the average SWP at 8-inch depth of -20 kPa or less. The Mini Field Stations were powered by solar panels and the Mini-P Field Station was powered by 120 V AC. The Automata system was started on June 24, 2004.

Watermark Monitor
Irrometer manufactures the Watermark Monitor datalogger that can record data from seven GMS and one temperature probe. The soil temperature is used to correct the SWP calibrations. Each of the three Watermark Monitor zones had seven GMS connected to a Watermark Monitor. Data were downloaded from the Watermark Monitor both by radio and with a laptop computer. The Watermark Monitors were powered by solar panels. Irrigation decisions were made daily by reading the GMS data from each Watermark Monitor. When the SWP reached -20 kPa the zone was irrigated manually for 8 hours. The Watermark Monitors were started on May 15, 2004.

Acclima
Acclima (Meridian, ID) manufactures a Digital TDT™ that measures volumetric soil moisture content. Each zone had one TDT sensor and four GMS. The TDT sensors were connected to a model CS3500 controller (Acclima) at the field edge. The controller monitored the soil moisture and controlled the irrigations for each zone separately using solenoid valves. The controller was powered by 120 V AC. Data was downloaded from the controller using a laptop computer. For comparison and calibration, the GMS were connected to the Campbell Scientific datalogger which monitored the soil water potential as described above. The Acclima system was started on May 16. The CS3500 controller was programmed to irrigate the zone when the volumetric soil water content was equal to or lower than 27 percent. The soil water potential data was compared to the volumetric soil water content data to adjust the CS3500 controller to irrigate each zone in a manner equivalent to the irrigation scheduling using the GMS (Fig. 1). Due to excessive soil moisture, on June 11 the lower threshold at which irrigations were started was changed from 27 percent to 19 percent, and 21 percent for Acclima zones one and two, respectively, to correspond to -20 kPa soil water potential. When installed, due to a software constraints, the controller could only water a maximum of 4 hours at each irrigation. On July 21 the software was upgraded allowing irrigation durations to be increased to 8 hours. Given the flow rate of the drip tape, 8 hour irrigations applied 0.48 inches of water. Previous research indicates that the ideal amount of water to apply at each irrigation is 0.5 inches (Shock et al., 2004).

All soil moisture sensors in every zone of the four systems were installed at 8-inch depth in the center of the double onion row. The GMS were calibrated to SWP (Shock et al. 1998). The Campbell Scientific, Acclima, and Automata controllers were programmed to make irrigation decisions every 12 hours: zones were irrigated for 8 hours if the soil moisture threshold was exceeded. The Campbell Scientific and Automata dataloggers used an average soil water potential at 8-inch depth of -20 kPa or less as the irrigation threshold. The Irrometer zones also had a threshold of -20 kPa. The amount of water applied to each plot was recorded daily at 8:00 a.m. from a water meter installed downstream of the solenoid valve. The total amount of water applied included sprinkler irrigations applied after emergence and water applied with the drip irrigation system from emergence through the final irrigation.

Onion evapotranspiration (ET_c) was calculated with a modified Penman equation (Wright 1982) using data collected at the Malheur Experiment Station by an AgriMet weather station (U.S. Bureau of Reclamation, Boise, Idaho). Onion Et_c was estimated and recorded from crop emergence until the final irrigation on September 2.

On September 24 the onions were lifted to field cure. On September 27, onions in the central 40 ft of the middle four double rows in each zone were topped and bagged. On September 28 the onions were graded. Bulbs were separated according to quality: bulbs without blemishes (No. 1s), double bulbs (No. 2s), neck rot (bulbs infected with the fungus *Botrytis allii* in the neck or side), plate rot (bulbs infected with the fungus *Fusarium oxysporum*), and black mold (bulbs infected with the fungus *Aspergillus niger*). The No. 1 bulbs were graded according to diameter: small (< 2¼ inch), medium (2¼ 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 zone of every variety by weighing and counting all supercolossal bulbs during grading.

Differences in onion performance and water application among irrigation systems were determined by protected least significant differences at the 95 percent confidence level using analysis of variance (Hintze, 2000).

Results and Discussion

Marketable onion yield was excellent, averaging 1,041 cwt/acre (116.6 Mg/ha) over the 4 drip irrigation systems (Table 1). The average onion bulb yield in the Treasure Valley was 625 cwt/acre (70.0 Mg/ha) in 2000, 630 cwt/acre (70.6 Mg/ha) in 2001, and 645 cwt/acre (72.2 Mg/ha) in 2002 (USDA 2003). The excellent onion performance with all the systems used was consistent with the maintenance of SWP within the narrow range required by onion (Shock et al. 1998b, 2000).

A comparison of the systems in terms of onion yield and grade is not completely justified because the systems were started at different times. In addition, the Acclima and

Automata systems required adjustments and modifications after the start of operation.

The Acclima system resulted in among the lowest marketable yield and yield of colossal bulbs. The Acclima system maintained the soil very wet at the beginning of the season due to our lack of knowledge of the appropriate volumetric soil water content that corresponded to ideal SWP (Figs. 2 and 3). After changes were made to the irrigation threshold for each Acclima zone separately (Fig. 1), the soil volumetric water content (Fig. 3) was very stable with some seasonal deviations from the target SWP of -20 kPa (Fig. 2). Due to initial software limitations, the Acclima system had irrigation durations of 4 hours until July 21. After July 21 the software was upgraded and the irrigation durations were increased to 8 hours. Irrigation durations of less than 8 hours have been shown to reduce onion yield (Shock et al. 2004). Also, early heavy irrigation could have leached nitrate needed for optimal onion growth.

The Campbell Scientific and Automata maintained the SWP relatively constant and close to the target of -20 kPa (Fig. 4). The Irrometer Watermark Monitors maintained the SWP on target, but with larger oscillations than the other systems, due to human collection of the SWP data and human control of irrigation onset and duration (Fig. 4).

Water applications over time followed ET_c during the season (Fig. 5). The total water applied plus precipitation from emergence to the end of irrigation on September 2 was 31.5, 40.0, 43.9, and 36.2 inches (800, 1,016, 1,115, and 919 mm) for the Campbell Scientific, Irrometer, Automata, and Acclima systems, respectively. Precipitation from onion emergence until irrigation ended on September 2 was 3.88 inches (99 mm). Onion evapotranspiration for the season totaled 30.9 inches (785 mm) from emergence to the last irrigation. The Automata system used a new version of software that had initial bugs to work out. The Acclima system over-applied water when first installed, until the irrigation thresholds were adjusted downwards.

Conclusions

All the systems tested performed well in this preliminary evaluation. Onion yield, grade, and quality were excellent. Any small shortcomings in precise irrigation may have been due to our unfamiliarity and inexperience using these systems.

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Table 1. Onion yield and grade for a drip-irrigated onion field irrigated automatically by four systems, Oregon State University Malheur Experiment Station, Ontario, OR 2004.

System	Total yield	Marketable yield by grade					Super-colossal counts	Nonmarketable yield		
		Total	>4¼ in	4-4¼ in	3-4 in	2¼-3 in		Total rot	No. 2s	Small
	---------- cwt/acre ----------						#/50 lb	% of total yield	-- cwt/acre --	
Campbell Sci.	1035.9	1026.1	21.4	258.5	727.4	18.8	42.6	0.5	1.3	3.1
Irrometer	1081.4	1076.1	36.2	337.2	685.6	17.1	39.5	0.2	0.0	3.4
Automata	1072.4	1064.0	18.2	306.0	724.6	15.2	41.8	0.4	1.5	2.2
Acclima	1008.4	997.9	15.7	215.2	746.4	20.6	47.9	0.3	3.7	4.2
Average	1049.5	1041.0	22.9	279.2	721.0	17.9	43.0	0.3	1.6	3.2
LSD (0.05)	51.2	52.0	NS	86.5	NS	NS	NS	NS	NS	NS
	---------- Mg/ha ----------						#/50 lb	% of total yield	-- Mg/ha --	
Campbell Sci.	116.0	114.9	2.4	29.0	81.5	2.1	42.6	0.5	0.2	0.4
Irrometer	121.1	120.5	4.1	37.8	76.8	1.9	39.5	0.2	0.0	0.4
Automata	120.1	119.2	2.0	34.3	81.2	1.7	41.8	0.4	0.2	0.3
Acclima	112.9	111.8	1.8	24.1	83.6	2.3	47.9	0.3	0.4	0.5
Average	117.5	116.6	2.6	31.3	80.8	2.0	43.0	0.4	0.2	0.4
LSD (0.05)	5.7	5.8	NS	9.7	NS	NS	NS	NS	NS	NS

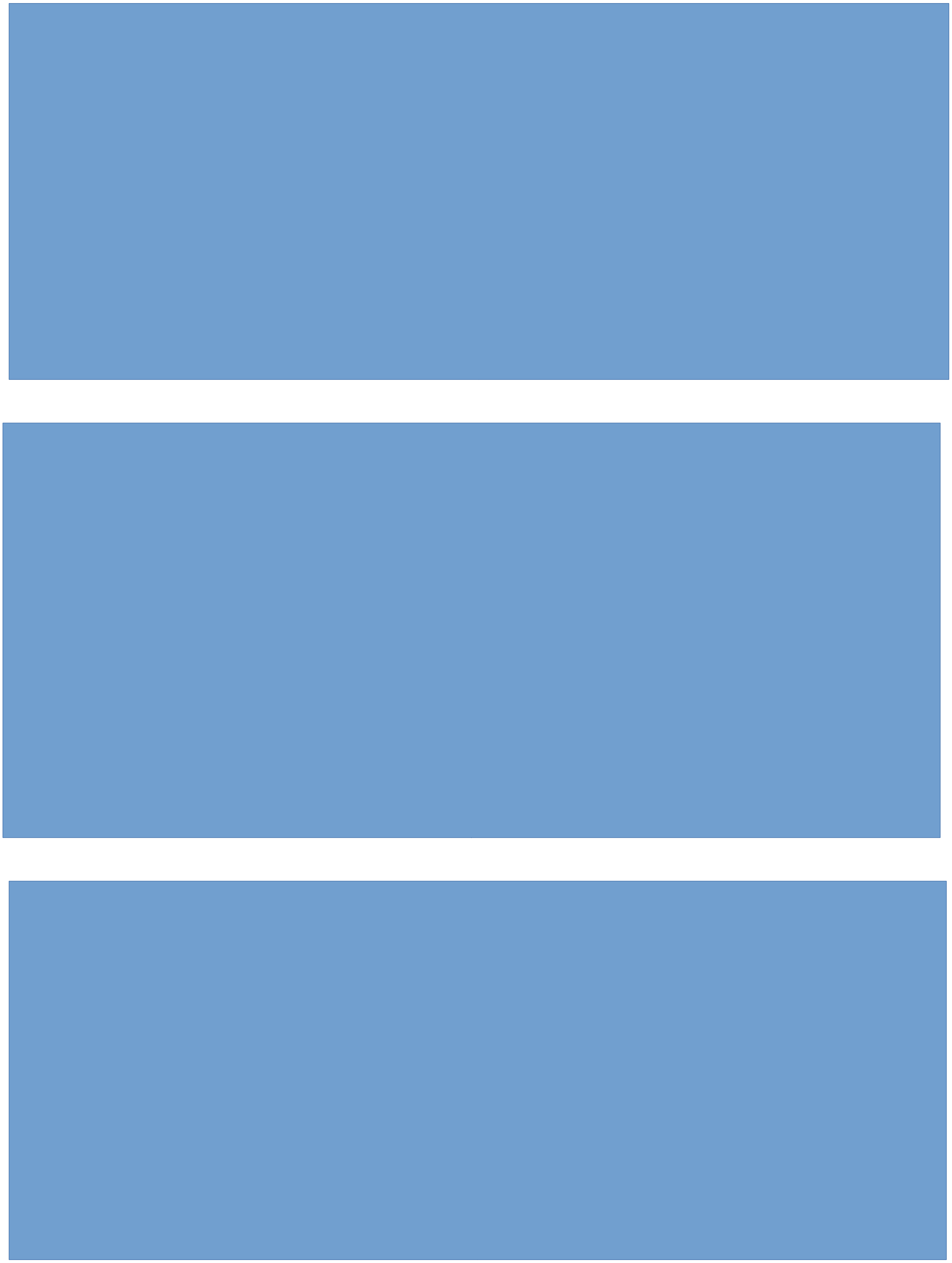

Figure 1. Regressions of volumetric soil water content from Acclima TDT sensors

against soil water potential from Watermark soil moisture sensors for each Acclima plot. Malheur Experiment Station, Oregon State University, Ontario OR.

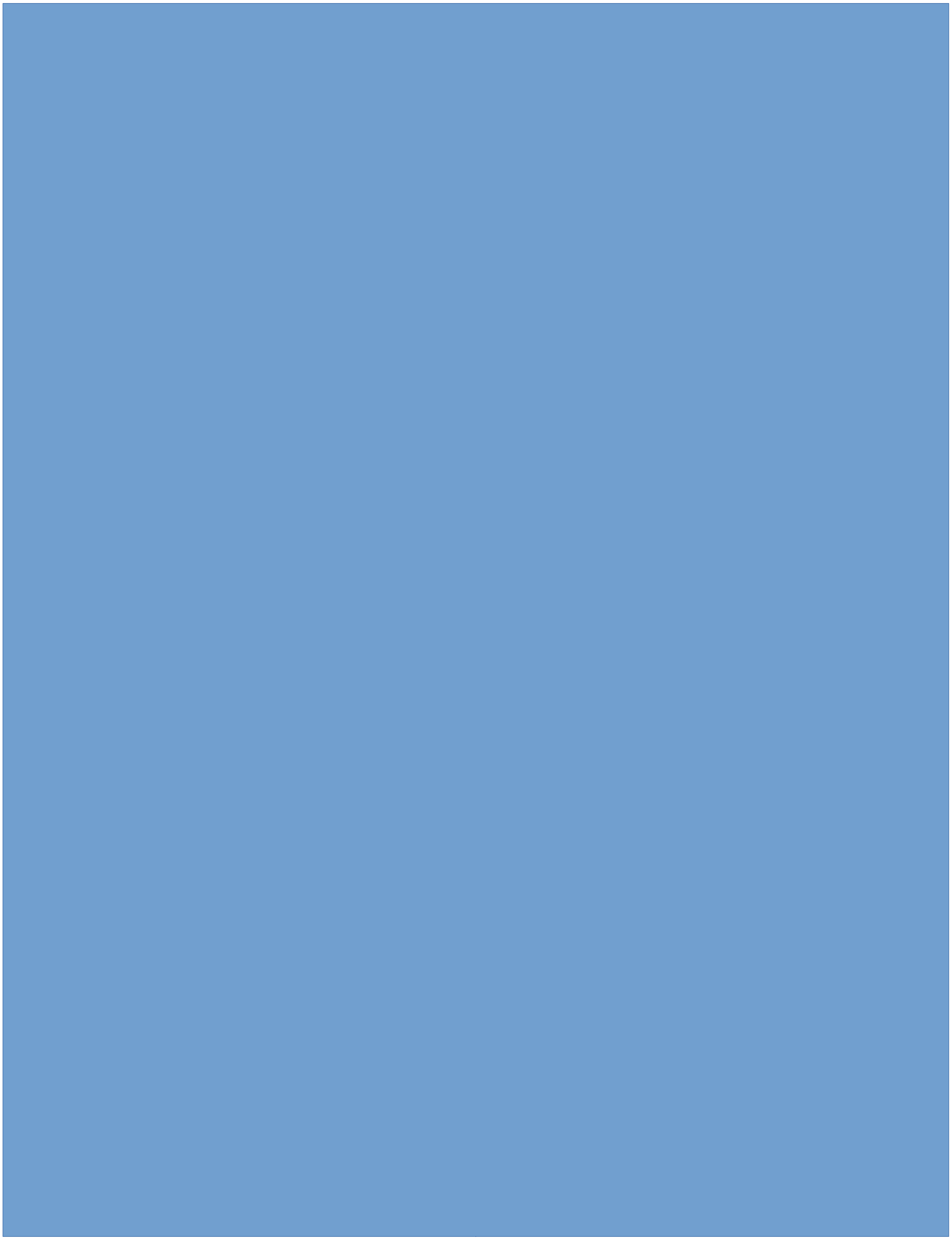

Figure 2. Soil water potential at 8-inch depth for a drip-irrigated onion field using the Acclima automated irrigation system with 3 irrigation thresholds, Oregon State University Malheur Experiment Station, Ontario, OR 2004.

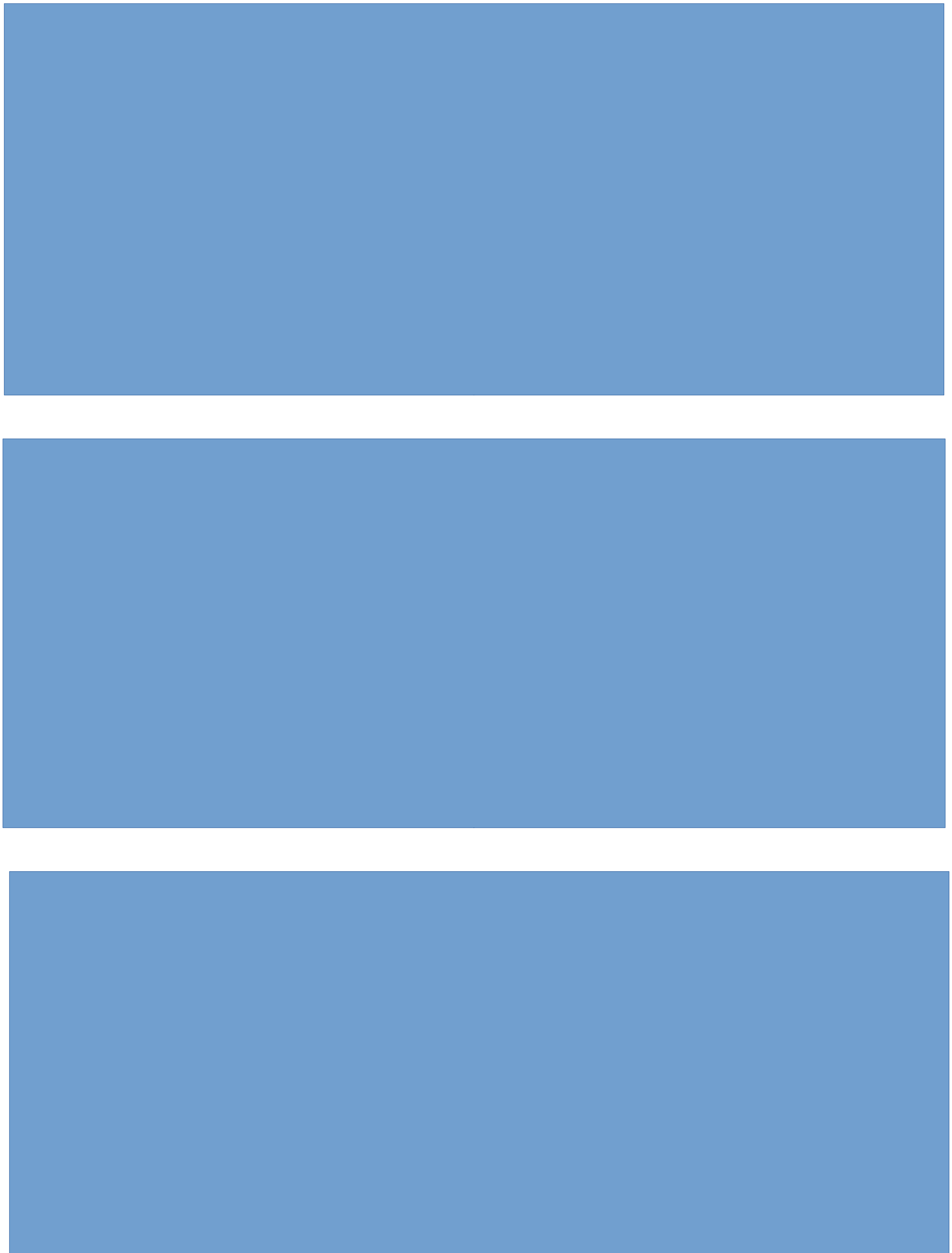

Figure 3. Volumetric soil water content at 8-inch depth for a drip-irrigated onion field using the Acclima irrigation system with 3 soil water content irrigation thresholds, Oregon State University, Malheur Experiment Station, Ontario, OR 2004.

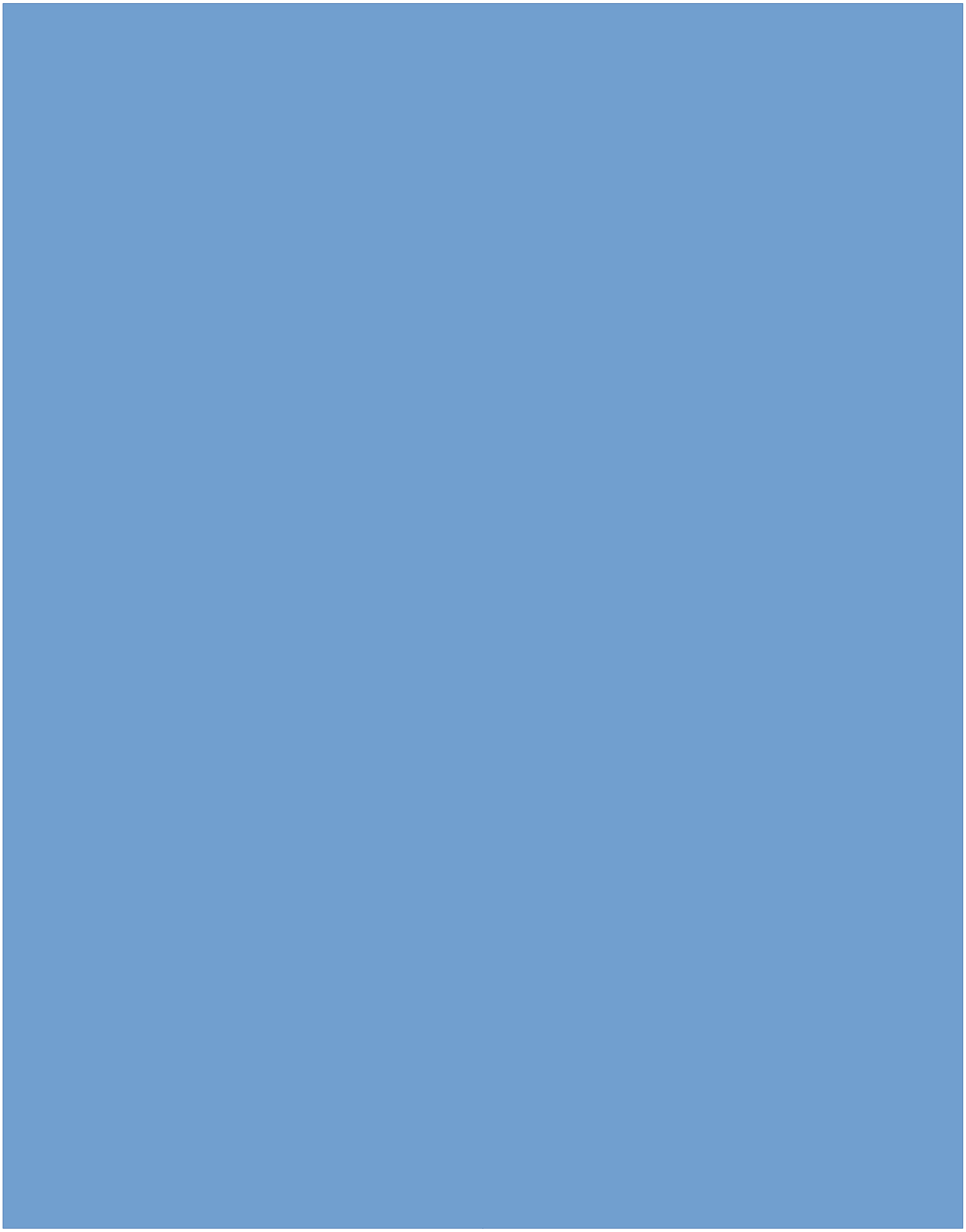

Figure 4. Soil water potential at 8-inch depth for a drip-irrigated onion field using 3 automated irrigation systems, Oregon State University Malheur Experiment Station, Ontario, OR 2004.

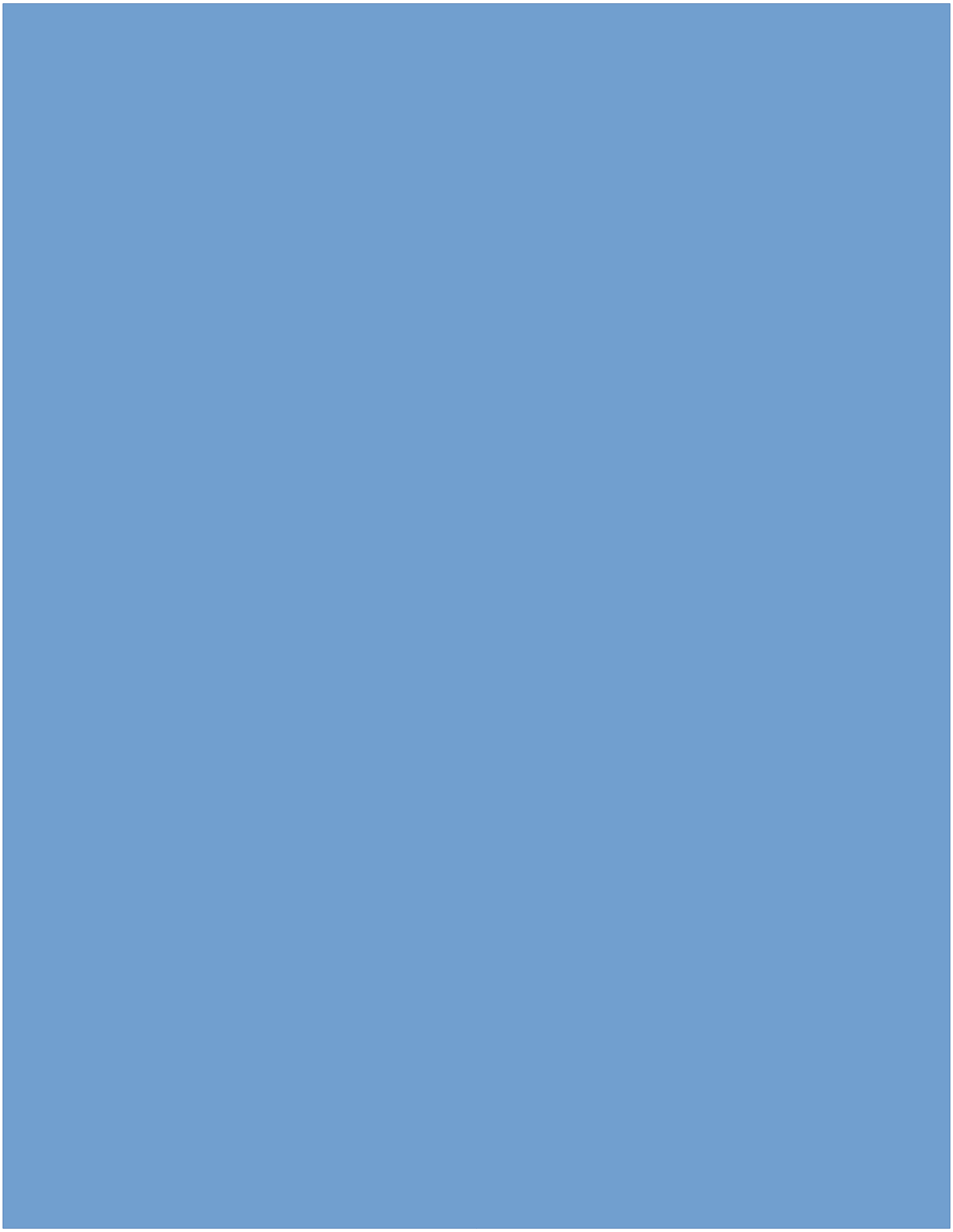

Figure 5. Water applied plus precipitation over time for drip-irrigated onions with 4 automated irrigation systems. Thin line is water applied and thick line is ET_c, Oregon State University Malheur Experiment Station, Ontario, OR 2004.

USE OF IRRIGAS® FOR IRRIGATION SCHEDULING FOR ONION UNDER FURROW IRRIGATION

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Introduction

Irrigation scheduling consists of applying the right amount of water at the right time. Incentives to onion (*Allium cepa* L.) growers for precise irrigation scheduling are based on the fact that underirrigation leads to a loss in market grade, bulb quality, and contract price, whereas overirrigation leads to a loss in water, electricity for pumping, leaching of nitrogen, and it may favor weeds and wastes labor. Overirrigation results in soil erosion, increases the potential for contamination of surface and groundwater, and requires additional chemicals and fertilizers. One of the several tools growers can use to schedule irrigation is based on the monitoring of soil water potential (SWP) and a criterion has been established at –27 kPa for furrow-irrigated onion grown on silt loam (Shock et al. 1998b). The SWP is of direct importance to plants because it reflects the force necessary to remove water from the soil.

This trial had the following objectives: 1) to evaluate the performance of six different kinds of soil moisture sensors in a furrow-irrigated onion field; 2) to compare the irrigation criterion of the Irrigas® to that defined by previous research carried out at the Malheur Experiment Station for onions under furrow irrigation; and 3) to verify if the nominal functioning pressure of the Irrigas performs reliably through wetting and drying cycles on silt loam in eastern Oregon, and observe onion yield and quality.

Materials and Methods

Six types of soil moisture sensors were compared by their response to wetting and drying in furrow-irrigated onion grown on Owyhee silt loam at the Malheur Experiment Station. Seeds were planted on 17 March 2004 in double rows on 22-inch beds. The double onion rows were spaced 3 inches apart. The sensors were tensiometers with pressure transducers (Irrometers, Irrometer Co. Inc., Riverside, CA, Model RA), ECH_2O dielectric aquameter (Decagon Devices, Inc., Pullman, WA), granular matrix sensors (GMS, Watermark soil moisture sensors Model 200SS, Irrometer Co., Inc.), Irrigas (National Center for Horticultural Research of EMBRAPA, Brasilia, DF, Brazil), and two experimental granular matrix sensors not described further here. Sensors were installed at 8-inch depth below the double row of onions on 15 July 2004 and replicates were spread 60 ft apart down an irrigation furrow in a 3-acre field. The statistical design was a randomized complete block with four replicates.

Tensiometers, GMS, and ECH_2O dielectric aquameters were attached to three AM416 multiplexers (Campbell Scientific, Logan, UT) that in turn were wired to a CR 10X datalogger (Campbell Scientific), which was programmed to make readings once an hour. Two temperature sensors were installed at 8-inch depth to allow for temperature corrections of GMS readings. Data were collected from the datalogger using a laptop computer. Each replicate contained two tensiometers, two GMS, one ECH_2O dielectric aquameter, and two Irrigas. The ECH_2O dielectric aquameters were calibrated against volumetric soil water content by taking two soil samples near each probe centered at 8-inch depth, once when the soil was relatively wet, and once when the soil was relatively dry, and by preparing oven-dry soil and placing the probes in the oven-dry soil at the end of the trial. Gravimetric data were converted to volumetric water contents using soil bulk density. Irrigas operates on the principle of air permeability of porous ceramics explained below. Data were collected from all sensors from July 15 to September 30, 2004.

Air permeability of porous ceramics has been used to estimate SWP (Kemper and Amemiya 1958). Air permeability of a specific porous ceramic is a function of its water content. As water dries from the ceramic, the pores allow the passage of air. The "initial bubbling pressure" (IBP) of a water-saturated porous ceramic is the lowest applied pressure at which air permeability is observed.

The IBP of a specific porous ceramic can be used to estimate whether a soil has reached a specific SWP used as an irrigation criterion. The National Center for Horticultural Research of EMBRAPA, Brazil used IBP to develop a SWP indicator, Irrigas (Calbo 2004; Calbo and Silva 2001). Irrigas consists of a porous ceramic cup, a flexible tube, a transparent barrel, a rigid thin plastic support, and a moveable container of water. The porous ceramic cup is installed in the effective rooting zone of the crop and connected to a small transparent barrel by means of the flexible tube. The porous ceramic cup is designed to retard free air movement out of the cup until the soil and cup reach a predetermined water potential. To make a reading, the barrel is immersed in the container of water. The free air passage through the porous ceramic cup gets blocked whenever the soil water saturates the pores in the ceramic. As the soil dries, its moisture drops below a critical tension value, and the porous cup becomes permeable to air passage. In dry soils when the barrel is immersed into the water, the meniscus (air-water boundary) rapidly moves upwards in the barrel to equalize it to the water level in the container. Whenever water enters the barrel, the soil is at least as dry as the calibration of the porous ceramic cup. The soil moisture is evaluated once a day to determine the moment to irrigate. In sandy soils the evaluation is made twice a day.

The Irrigas had a nominal calibration of -25 kPa and when we subjected Irrigas to progressive amounts of suction, the porous ceramic freely bubbled air at -25 kPa. Irrigas readings were taken every day at 9:00 AM.

The onion crop was irrigated at -25 kPa throughout the season based on average GMS readings (Shock et al. 1998b). With the establishment of this experiment in an onion field, the onions in the entire sensor calibration trial were irrigated when the average

GMS reading reached -25 kPa on July 17 and 22. Since the Irrigas had not provided positive readings, the next five irrigations were delayed until at least half of the eight Irrigas sensors indicated the need for irrigation.

The onions were lifted on September 8 to field cure. Onions from the middle two rows in each replicate were topped by hand and bagged on September 15. Onions were graded on September 16. During grading, bulbs were separated according to quality: bulbs without blemishes (No. 1s), split bulbs (No. 2s), neck rot (bulbs infected with the fungus *Botrytis allii* in the neck or side), plate rot (bulbs infected with the fungus *Fusarium oxysporum*), and black mold (bulbs infected with the fungus *Aspergillus niger*). The No. 1 bulbs were graded according to diameter: small (<2.25 inches), medium (2.25-3 inches), jumbo (3-4 inches), colossal (4-4.25 inches), and supercolossal (>4.25 inches). Bulb counts per 50 lb of supercolossal onions were determined for each plot of every variety by weighing and counting all supercolossal bulbs during grading.

Results and Discussion

All the sensors used in this study had advantages of low unit cost and simple installation procedures. Both tensiometers and GMS demonstrated similar responsiveness to wetting and drying of the soil (Fig. 1). In this trial, there were two episodes of irrigation based on GMS readings at –25 kPa and five irrigation events based on the Irrigas criterion (Fig. 1). It took the same amount of time (4 hours) for all the tensiometers and all GMS to indicate that the soil at 8-inch had reached saturation after the onset of each irrigation episode. The relative similarity in responsiveness between tensiometers with pressure transducers and granular matrix sensors (GMS) was statistically confirmed by regression with a coefficient of determination of 0.92 (Fig. 2). The Irrigas indicated free air permeability close to -35 kPa for Owyhee silt loam in this trial (Fig. 1).

Large changes in tensiometer readings from -10 to -40 kPa translated into small changes in water content readings for the ECH_2O dielectric aquameter (Fig. 3). The exact responsiveness of the ECH_2O dielectric aquameter to the soil water content was beyond the scope of this work. A comparison of the ECH_2O dielectric aquameter readings with soil volumetric water content from this field indicated that the readings were relatively flat and nonlinear in response to changes in volumetric soil water content (Fig. 4). The relatively small changes in volumetric soil water content as read by the ECH_2O dielectric aquameter occurred across the critical range of SWP for onion irrigation decisions.

The ECH_2O dielectric aquameter was relatively easy to automate. The ECH_2O dielectric aquameter was used in only one experiment and the readings were relatively unresponsive to changes in soil water potential in the range of -10 to -40 kPa (Fig. 3) and relatively unresponsive to changes in volumetric soil water content in the range of 23 to 38 percent (Fig. 4). The need for site specific calibrations noted here for the ECH_2O dielectric aquameter is consistent with the work of Evett et al. (2002), who tested a variety of capacitance probes in widely divergent soils and recommended site specific calibrations.

The tensiometers with pressure transducers were easily automated. The tensiometers required servicing twice during the 76 days of the trial. More frequent servicing to replace lost water should be expected when soils are not maintained as wet as in the present experiment. The GMS have limitations in reading SWP in soils wetter than –10 kPa (Fig. 2), as has been described previously (Shock et al. 1998a), and in responding in coarse texture soils (Shock 2003).

The model of Irrigas was only tested in one comparison experiment, where it appeared to be promising for irrigation scheduling at –35 kPa in silt loam, not the nominal specifications of –25 kPa. Kemper and Amemiya (1958) pointed out that soil particles which surround and are in contact with a porous ceramic could cut down on air permeability to some extent. From the limited experience of this trial, the interference of the soil with air permeability of porous ceramics is a possibility for further study. We would expect greater interference in fine textured soils at relatively high (wetter) SWP and less interference with coarse textured soils and at relatively low (drier) SWP.

Scheduling furrow irrigations at a criterion near -27 kPa has been shown to optimize long-day onion yield and grade (Shock et al. 1998b). However, perhaps the Irrigas irrigation threshold of -35 kPa for August through the end of growing season may not have been detrimental and may bring about a convenient reduction in irrigation frequencies. An Irrigas type instrument could probably be manufactured with porosity designed specifically for measurements at -25 kPa in silt loam.

The irrigation scheduling used in this field trial appeared to be adequate, since there was an average onion marketable yield of 993 cwt/acre. Average marketable onion yield for 2000 through 2002 from commercial production in the Treasure Valley was 633 cwt/acre.

Acknowledgments

We would like to thank Adonai Gimenez Calbo from CNPH-EMBRAPA, Brasilia, DF, Brazil, and Enison Pozzani from E-Design, Jundiai, SP, Brazil, for providing 8 -25 kPa Irrigas for testing. We would also like to thank Conselho de Desenvolvimento Cientifico e Tecnologico (CNPq) of Brazil for providing the Post-Doctoral scholarship and support from Oregon State University that enabled this work.

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Figure 1. Soil water potential over time for tensiometers with pressure transducers and granular matrix sensors in a furrow-irrigated onion trial. Arrows denote furrow irrigations with 75 mm of water applied. The last five irrigations started based on Irrigas. Malheur Experiment Station, Oregon State University, Ontario, OR 2004.

Figure 2. Soil water potential measured in a furrow-irrigated onion trial by a tensiometer with transducers (X axis) regressed against soil moisture suction measured by a

granular matrix sensor (Y axis). Data points are the average of eight instruments. Malheur Experiment Station, Oregon State University, Ontario, OR 2004.

Figure 3. Soil water potential measured in a furrow-irrigated onion trial by a tensiometer with transducers (X axis) regressed against volumetric soil water content measured by an ECH_2O dielectric aquameter (Y axis). Data points for soil water potential are the average of eight tensiometers. Data points for the ECH_2O dielectric aquameter are the average of four sensors. Malheur Experiment Station, Oregon State University, Ontario, OR 2004.

Figure 4. Regression of the volumetric soil water content measured by an ECH_2O dielectric aquameter (X axis) against the classical gravimetric method (Y axis). Data

points from each of four ECH$_2$O dielectric aquameters were compared with two soil samples in each of three soil moisture ranges. Malheur Experiment Station, Oregon State University, Ontario, OR 2004.

FACTORS INFLUENCING VAPAM® EFFICACY ON YELLOW NUTSEDGE TUBERS

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Introduction

Yellow nutsedge is a perennial weed common in irrigated row crop production in the Treasure Valley of Eastern Oregon and Southwestern Idaho. It is particularly problematic in onion production. Onion plants are relatively short in stature with vertical leaves producing an incomplete canopy with limited potential to effectively suppress weeds. The conditions of high light intensity as well as frequent irrigation and high nitrogen fertilization required to maximize onion yield also serve to stimulate yellow nutsedge growth (Keeling et al. 1990). We have demonstrated that without any competition a single yellow nutsedge plant can produce over 18,000 tubers in a single year (Rice et al. 2004). We have also found that heavily infested commercial fields can have as high as 1,800 tubers/ft^2 in the top 10 inches of soil (unpublished data). Producers often apply Vapam® (metham sodium) in the fall prior to planting onions in an attempt to control yellow nutsedge. Control with Vapam is often variable and seems to depend on a number of environmental factors. The objective of this research was to determine the effect of metham rate, duration of exposure, temperature of exposure, and yellow nutsedge tuber condition on metham sodium efficacy.

Materials and Methods

Trials were conducted at the Malheur Experiment Station in the laboratory to determine the influence of metham sodium rate, duration of exposure, temperature during exposure, and tuber conditioning on yellow nutsedge control. Yellow nutsedge tubers were extracted from the soil in November and either stored at a constant 50°F in a small volume of soil or washed and subjected to 38°F for 4 weeks prior to the initiation of the experiment. The conditioning treatment was meant to reduce tuber dormancy. Washing and chilling have been reported as effectively overcoming dormancy (Tumbleson and Kommedahl 1961). All tubers were produced from a single plant the previous summer. Soil (1.76 lb) and 15 tubers were placed in 1-quart jars. The soil was an Owyhee silt loam. The soil was wetted to 14 percent moisture on a weight for weight basis by adding one third of the water to the bottom of the jar, adding half the volume of soil and then the yellow nutsedge tubers, adding another third of water, adding the remaining soil and then the final third of the water. The jars were placed in growth chambers at 41, 55, or 77°F for 24 hr to equilibrate. Vapam was injected into the soil 0.5 inch below the tubers at equivalent field rates of 0, 20, 40, 60, and 80 gal of product per acre based on soil volume. Jars were sealed and placed back in their respective temperatures for 1, 3, or 5 days. After each duration of exposure, the soil was removed from the jars and the tubers were washed from the soil. Extracted tubers were placed in petri-dishes between 2 pieces of filter paper and 5 ml of water was added to each dish. The petri-dishes were sealed and placed in the dark at 77°F. Germinated tubers were recorded at the time of removal and weekly for 6 weeks. Treatments were replicated four times and the trial was repeated once after the initial run. Total percent tuber germination was analyzed by ANOVA. For each combination of exposure temperature, exposure duration, and tuber conditioning, tuber sprouting response to Vapam dose was fitted to the logistic model:

$$y = \frac{D - C}{1 + (x / I_{50})^{b}}$$

Where y = the percent sprouting yellow nutsedge tubers, x = metham sodium rate, C = percent tubers sprouting at high rates, D = percent of tubers sprouting in the non-treated treatment, b = the slope at the I_{50} dose, and I_{50} = the dose providing 50 percent reduction in sprouting tubers (Seefelt et al. 1995).

Results and Discussion

In general, tuber sprouting was affected by metham sodium rate, temperature of exposure, duration of exposure, and yellow nutsedge tuber conditioning. This is in agreement with research by Boydston and Williams (2003), which evaluated fumigant affects on volunteer potatoes. All main effects and interactions were significant (Table 1). The I_{50} dose for metham sodium under various conditions ranged from 21.64 to >80.0 gal/acre and was lower for conditioned tubers compared to nonconditioned tubers across all conditions except for tubers exposed at 77°F for 3 or 5 days (Table 2). Non-conditioned tubers had lower germination in preliminary trials (data not shown), but washing and other conditions during the trial overcame any dormancy as D values (maximum germination) were similar among all treatments. Nonconditioned tubers did require more time to germinate than conditioned tubers (data not shown). Nonconditioned tubers were unaffected by metham sodium rate at 1 day exposure at 41°F (Fig. 1). For nonconditioned tubers, increasing exposure temperature, and increasing duration of exposure decreased sprouting. As duration of exposure or temperature of exposure increased, differences among conditioned and nonconditioned tubers decreased. Metham Sodium must be converted to methyl isothiocyanate (MITC) to have activity against yellow nutsedge. At lower temperatures conversion of metham sodium to MITC takes place at a slower rate. In addition to slow conversion of metham to MITC, the reduced response of yellow nutsedge tubers at cooler temperatures could also be attributed to yellow nutsedge tubers being less metabolically active. The similar response of conditioned tubers regardless of duration of exposure at 59 or 77°F and the increased response of nonconditioned tubers to increasing duration of exposure, suggests that at 59 and 77°F metham sodium conversion to MITC is not the limiting factor, but rather uptake by the nonconditioned nutsedge tubers may have been the limiting factor. In contrast, at 41°F, both conditioned and nonconditioned tubers responded to increasing duration of exposure, suggesting that both rate of metham sodium conversion to MITC and uptake by the tubers were having an affect on metham sodium efficacy. I_{50} values were actually lower for conditioned tubers exposed for 5 days at 41°F compared to 59 or 77°F. This result is difficult to explain. It may be that while conversion of metham sodium to MITC is faster at high temperatures, breakdown of MITC is also increased. This research illustrates that fumigant efficacy depends on the dose reaching the target organism. While the rate applied directly influences the dose, environmental or physiological factors may affect what dose the yellow nutsedge receives. Applying metham sodium at a time when yellow nutsedge tubers are more susceptible may increase metham sodium efficacy against yellow nutsedge.

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Acknowledgement

Thanks to the Idaho/Eastern Oregon Onion Growers Association for financial support.

Table 1. Significance of ANOVA main effects and interactions for total percent of yellow nutsedge tubers sprouting.

Factor	*P*
Dose	0.00001
Temperature	0.00001
Time	0.00001
Conditioning	0.00001
Dose by temperature	0.00001
Dose by time	0.00001
Temperature by time	0.00001
Conditioning by dose	0.00001
Conditioning by temperature	0.00001
Conditioning by time	0.00001
Dose by temperature by time	0.00001
Dose by temperature by conditioning	0.00001
Temperature by time by conditioning	0.00001
Dose by time by conditioning	0.00001
Dose by temperature by time by conditioning	0.00001

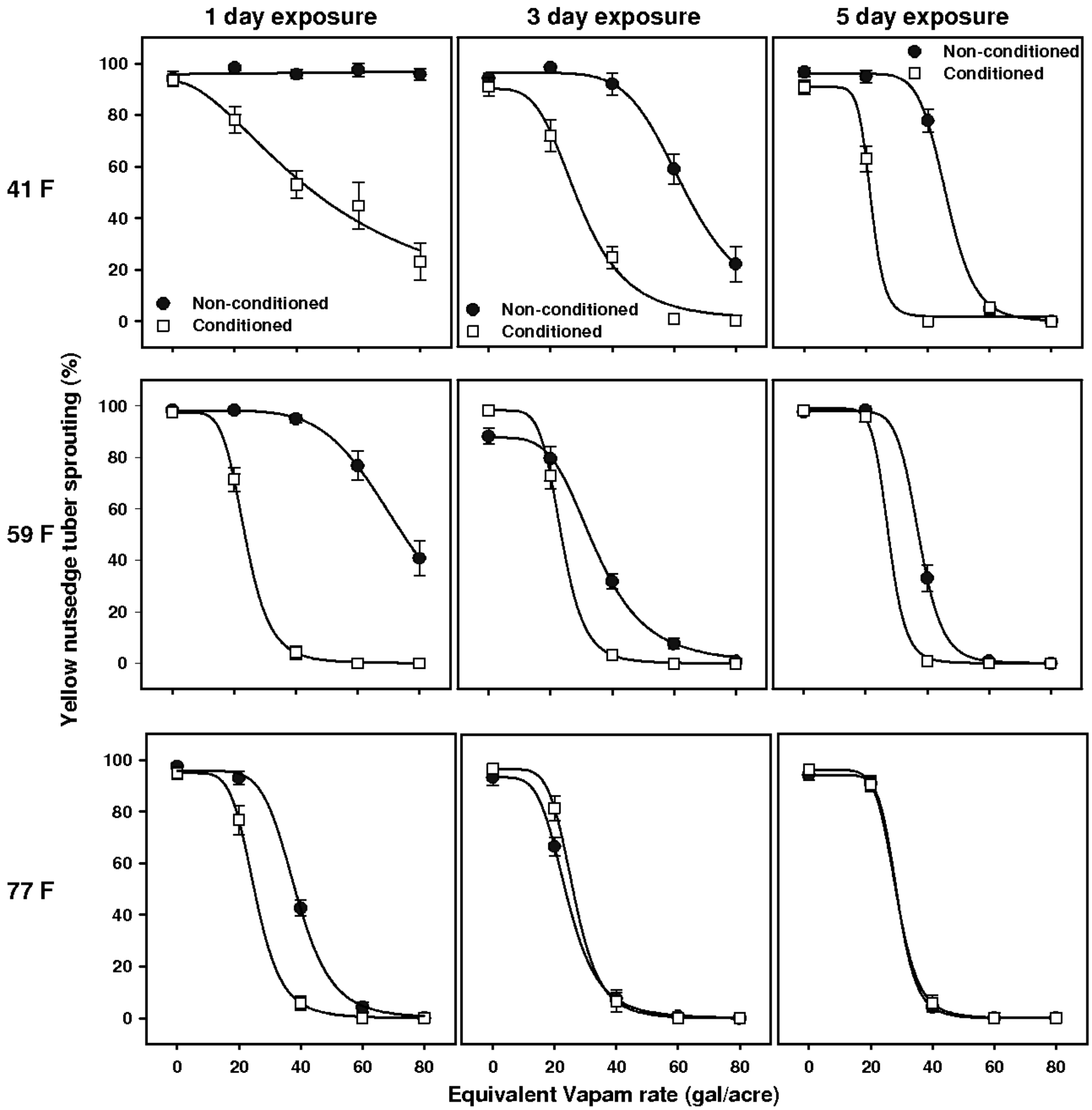

Figure 1. Yellow nutsedge germination in response to Vapam® rate, temperature of exposure, duration of exposure, and conditioning of the yellow nutsedge tubers. Conditioned tubers were washed and chilled at 38°F for 4 weeks prior to trial initiation. Nonconditioned tubers were stored in soil at a constant 50°F. Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 2. Estimated parameters for nonlinear regression analysis of yellow nutsedge sprouting in response to Vapam® rate, exposure temperature, exposure duration, and yellow nutsedge tuber conditioning. Standard errors are in parentheses.*, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Temperature	Time	Tuber condition	*D*	*C*	I_{50}	*b*	R_2
°F	days		-------------------%----------------		gal/acre		
41	1	Nonconditioned	--	--	--	--	0.00
		Conditioned	93.16 (6.23)	0.00 (56.29)	49.57 (36.77)	1.82 (1.15)	0.65
	3	Nonconditioned	96.21 (3.21)	6.34 (26.29)	63.18 (7.10)	6.59 (3.73)	0.84
		Conditioned	89.99 (3.83)	0.00 (4.33)	29.57 (2.09)	3.80 (0.68)	0.92
	5	Nonconditioned	96.02 (1.87)	0.00 (2.96)	46.07 (1.32)	10.00 (1.67)	0.97
		Conditioned	90.84 (2.84)	1.69 (2.04)	21.64 (4.61)	10.00 (26.72)	0.96
59	1	Nonconditioned	98.20 (2.78)	0.00 (126.09)	75.24 (37.21)	5.57 (4.91)	0.80
		Conditioned	97.50 (2.37)	0.00 (1.86)	23.69 (0.95)	5.96 (1.14)	0.98
	3	Nonconditioned	87.78 (2.86)	0.00 (3.67)	34.82 (1.59)	4.28 (0.81)	0.95
		Conditioned	98.33 (2.46)	0.00 (1.88)	23.62 (1.05)	6.38 (1.44)	0.97
	5	Nonconditioned	98.01 (1.88)	0.00 (2.63)	37.36 (2.49)	10.00 (10.28)	0.98
		Conditioned	99.01 (1.04)	0.00 (0.75)	27.48 (0.93)	10.00 (0.99)	1.00
77	1	Nonconditioned	95.86 (1.64)	0.00 (2.65)	38.62 (0.63)	6.72 (1.76)	0.98
		Conditioned	94.99 (2.95)	0.00 (2.31)	25.37 (1.31)	6.02 (1.06)	0.96
	3	Nonconditioned	95.60 (2.86)	0.00 (2.22)	26.24 (1.31)	6.21 (0.94)	0.97
		Conditioned	93.33 (2.41)	0.00 (2.06)	24.15 (0.94)	4.83 (0.70)	0.97
	5	Nonconditioned	96.18 (2.11)	0.00 (1.45)	28.36 (1.26)	7.98 (0.99)	0.98
		Conditioned	94.16 (1.78)	0.00 (1.29)	28.64 (1.48)	9.20 (1.35)	0.99

*Abbreviations: *D*, percent of tubers sprouting in nontreated treatment; *C*, percent of tubers germinating at high metham dose; I_{50}, dose causing a 50 percent reduction in sprouting tubers; *b*, slope at I_{50} dose. For one treatment the I_{50} was higher than the rates evaluated.

YELLOW NUTSEDGE GROWTH IN RESPONSE TO ENVIRONMENT

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Introduction

Yellow nutsedge is a perennial weed common in irrigated row crop production in the Treasure Valley of eastern Oregon and southwestern Idaho. It is particularly problematic in onion production. Onions are relatively short statured plants with vertical leaves producing an incomplete canopy with limited potential to effectively suppress weeds. Yellow nutsedge has a C_4 photosynthetic pathway and therefore responds well to conditions of high light intensity that exist in onion production. Management practices including frequent irrigation and high nitrogen fertilization required to maximize onion yield also serve to stimulate yellow nutsedge growth (Keeling et al. 1990).

Yellow nutsedge reproduces and is dispersed primarily by tubers' that are formed at the apical ends of underground rhizomes. Tubers are produced in the upper 18 inches of the soil profile with the greatest concentration located in the upper 6 inches (Stoller and Sweet 1987, Tumbleson and Kommedahl 1961). After a period of dormancy, tubers germinate and produce shoots in subsequent growing seasons. Tubers may remain viable for 1-3 years, providing an effective means of survival. Asexual reproduction by yellow nutsedge tubers can be quite prolific. Tumbleson and Kommedahl (1961) reported that a single tuber produced 6,900 tubers the first fall after planting and 1,900 plants the following spring in an area of approximately $34ft^2$. Yellow nutsedge grows best where soil moisture is high (Bendixin and Nandihalli 1987). Garg et al. (1967) reported that nitrogen promotes vegetative growth over reproductive growth in yellow nutsedge, leading to increased basal bulb formation (and subsequent shoot production) as opposed to tuber formation.

Two trials were conducted in 2004 at the Malheur Experiment Station to evaluate yellow nutsedge growth with various environmental factors.

Methods

Yellow nutsedge emergence and growth as influenced by depth of germination
The objectives of this experiment were to 1) determine the depth from which a yellow nutsedge tuber can emerge in the field, 2) determine the date of emergence based on depth of burial, and 3) determine the growth (i.e., shoot and tuber production) potential based on burial depth.

Yellow nutsedge tubers were harvested from a plot from the previous year's irrigation trial on April 16, 2004. The tubers were washed from the soil, rinsed with deionized water, and placed in a refrigerator at 38.5°F for approximately 14 days. Both washing and chilling have been shown to effectively break tuber dormancy (Tumbleson and Kommedahl 1961, Bell et al. 1962). This was necessary to ensure that the tubers would readily germinate when buried and that any differences in emergence would be based on depth of burial and/or soil temperature and not differences in dormancy. Ten tubers were buried in a single container at a selected depth of either 2, 4, 6, 8, 10, 12, 14, 16, 18, or 24 inches on May 1. Each depth was replicated four times. Containers consisted of 10-inch-diameter pvc pipe. Temperature sensors were placed at 6, 12, 18, and 24 inches deep in 1 tube in each replication. Each container was irrigated by a single drip emitter with an output of 0.5 gal/hr. Watermark sensors (Irrometer Co. Inc., Riverside, CA) were buried 6 inches deep in every pot in the first and third replicate of the trial. Soil water potential was measured every morning. Irrigations were initiated each time the average of the Watermark sensors was greater than or equal to -20 kPa. Shoots were counted throughout the season and shoots and tubers were harvested on July 7.

Yellow nutsedge growth in response to irrigation and nitrogen fertilization
The objectives of this experiment were to 1) monitor patch expansion from a single yellow nutsedge tuber in the absence of crop competition over the course of one growing season, 2) evaluate the effects of selected irrigation regimes on yellow nutsedge growth, and 3) evaluate the effect of nitrogen fertilization on yellow nutsedge growth.

Tubers for this trial were harvested from a ditch bank, were washed from the soil, rinsed with deionized water, and stored in a refrigerator at 38.5°F for approximately 40 days. Tubers weighing from 0.18 to 0.2 g and measuring between 6 and 7 mm were selected and planted in flats in the greenhouse. Tubers of similar size and weight were selected because research has shown that tuber size can affect early plant vigor, with plants from smaller tubers being less vigorous. On June 4, a single germinated tuber with a shoot of at least 1 inch long was transplanted into the center of each circular plot of 6-ft diameter. Transplanted yellow nutsedge plants were used to ensure a more uniform date of establishment among the 18 individual plots. The circular plots consisted of 14-inch-wide galvanized valley flashing cut to a length of 19 ft with the ends riveted together to produce a circle with a diameter of 6 ft. The flashing was then buried approximately 10 inches deep in the soil. Prior to transplanting, each plot was drip irrigated to a soil moisture potential of -20 kPa to incorporate fertilizer applications and to provide similar moisture conditions for early yellow nutsedge establishment.

The trial consisted of 18 circular plots, 6 each for the 3 irrigation regimes and 3 each for the 2 fertilization levels split over the irrigation regimes. Irrigation water was applied to the plots through 6 drip emitters evenly spaced in a circular pattern, where each emitter was located 1.5 ft from the center of the plot. The 6 emitters had a combined output of 3.0 gal/hr. The values for irrigation criteria were -20, -50, and -80 kPa and were selected to represent soil moisture conditions similar to those in wheat, sugar beet, and dry bulb onion production systems, respectively. The 2 fertilization levels consisted of plots receiving nitrogen (N) (46 percent urea) at rates of either 90 or 268 lbs N/acre. All plots were fertilized before transplanting with 90 lbs phophorus/acre, 90 lbs sulfur/acre, 1 lb copper/acre, 1 lbs boron/acre, and 9 lbs magnesium/acre. Soil water potential was measured in each plot with a single Watermark soil moisture sensor installed at a 6-inch depth equidistant from the yellow nutsedge plant at the center of the plot and the drip line. Irrigation water was applied independently for each regime when the average 6-inch soil water potential from the 6 sensors reached either -20, -50, or -80 kPa. The sensors were read by a datalogger every 3 hours, and once every 12 hours irrigation was initiated using a solenoid valve if the soil water potential had exceeded the treatment criteria during the previous 12-hour period. Water meters were installed between the solenoid valves and the water line for each individual irrigation regime to record the amount of water applied daily.

Yellow nutsedge growth was measured initially by counting shoot numbers within each plot and by taking overhead digital images of each plot. At a point where shoots became too numerous to efficiently count, only overhead digital images were taken of each plot. These images were used to quantify the plot area that was covered by yellow nutsedge shoots using a software program produced at Oregon State University (OSU). Shoots and tubers were harvested from subsamples within each plot on September 29 and 30. Thirteen subsamples were collected across the 6-ft diameter of the plots. The subsamples consisted of 4.25-inch-diameter circles from which shoots were counted to estimate the total shoot number per plot. The shoots were then clipped at ground level and placed in bags to be dried. The dry weights were used to estimate the total above-ground biomass. Once the shoots were removed, a soil core measuring 4.25 inches in diameter by 8 inches in depth was taken from the same area where the shoots were removed. The individual core samples were bagged and recorded as to their location within the plot. The core samples were then emptied into a bucket with multiple 11/64-inch holes in the bottom and sides. Water was sprayed into the bucket to remove the soil from the tubers. The tubers were then counted and weighed and those numbers were used to estimate the total tuber population for each of the plots.

Results and Discussion

Yellow nutsedge emergence and growth as influenced by depth of germination

Plots where tubers were planted from 2 to 12 inches deep had an average of 1-5 shoots emerged on May 24, while deeper depths had no shoots for another week or more (data not shown). The time required for treatments to produce an average 5 shoots per plot ranged from 24 to 68 days after planting. The time required for 10 shoots per plot to emerge ranged from 34 to 55 days for burial depths up to 18 inches. The tubers buried at the 24-inch depth produced a maximum of 6 shoots at the time the plots were harvested. The average daily soil temperatures at 6, 12, 18, and 24 inches from planting through harvest are illustrated in Figure 1 and show that temperature extremes are greatest nearer the soil surface. If tubers were buried earlier in the year, we might expect to see greater differences among emergence dates based on differences in the time required for the soil at each depth to reach temperatures favorable for yellow nutsedge germination. Figure 2 shows the emergence of shoots as affected by planting depth from May 24 through June 7. At harvest, shoot numbers were similar in plots where tubers were planted from 2 to 16 inches deep (Table 1). Tubers planted 18 and 24 inches deep had fewer shoots than all other planting depths and the 24-inch depth had the least number of shoots. The average weight per shoot was less for 16-, 18-, or 24-inch depths compared to depths from 2 to 12 inches (data not shown). Tuber numbers were lower for plots where the planting depth was 14 inches or greater, with significant decreases as depth increased from 12 to 24 inches.

This research demonstrates that yellow nutsedge shoot emergence is delayed at depths below 12 inches. Those shoots that emerge are fewer in number and at depths below 16 inches are also smaller in size. This delay in emergence affects how many tubers can be produced, and it is reasonable to expect that the delay in emergence and reduction in individual shoot fitness would correlate with reduced competitiveness from yellow nutsedge emerging from depths greater than 14 inches in the soil.

Table 1. Yellow nutsedge shoot emergence and shoot and tuber production as influenced by depth of germination, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

	Time to emergence		Yellow nutsedge production*	
Depth of burial	Average ≥ 5 shoot/container[†]	Average ≥ 10 shoot/container[‡]	Shoots	Tubers
	--------- days after planting -----------		------------no/plot-----------	
2-inch	35	41	91 b	250 b
4-inch	25	39	115 ab	334 a
6-inch	24	34	101 ab	333 a
8-inch	27	39	126 a	313 ab
10-inch	27	39	108 ab	240 b
12-inch	31	39	119 a	272 ab
14-inch	39	40	119 a	167 c
16-inch	39	45	108 ab	97 cd
18-inch	45	55	66 c	30 de
24-inch	68	> 68	6 d	10 e

*Yellow nutsedge tubers were buried at the various depths on May 1, 2004, and yellow nutsedge shoots and tubers were harvested on July 7, 2004. Data followed by the same letter are not signficicant according to LSD (0.05).
[†]Days after planting for which the average of the 4 replicates for the given depth of burial were greater than or equal to 5.
[‡]Days after planting for which the average of the 4 replicates for the given depth of burial were greater than or equal to 10.

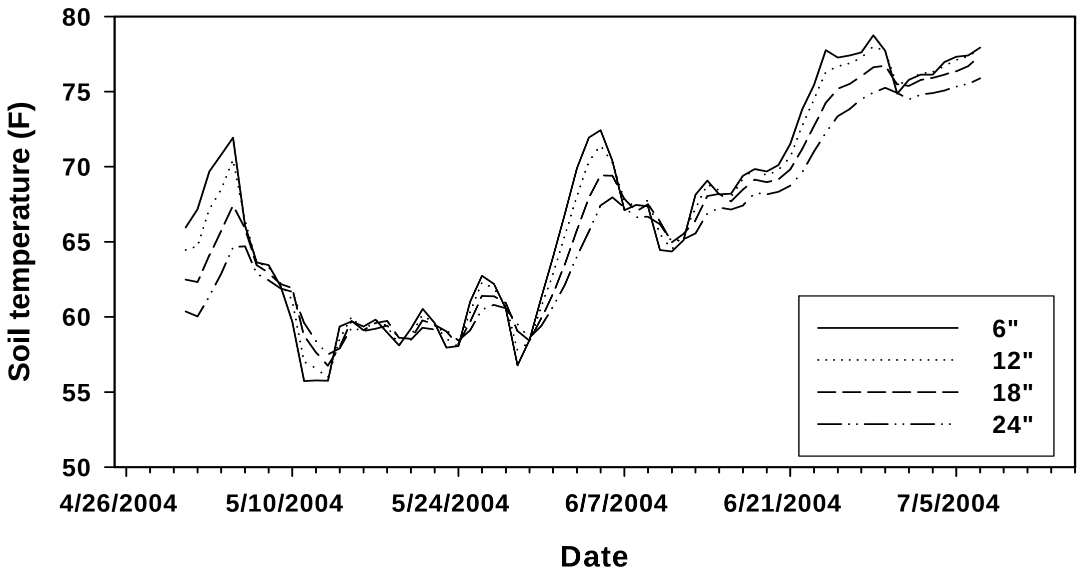

Figure 1. Average daily soil temperature at 6-, 12-, 18-, and 24- inch depths from yellow nutsedge tuber planting up to shoot and tuber harvest, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

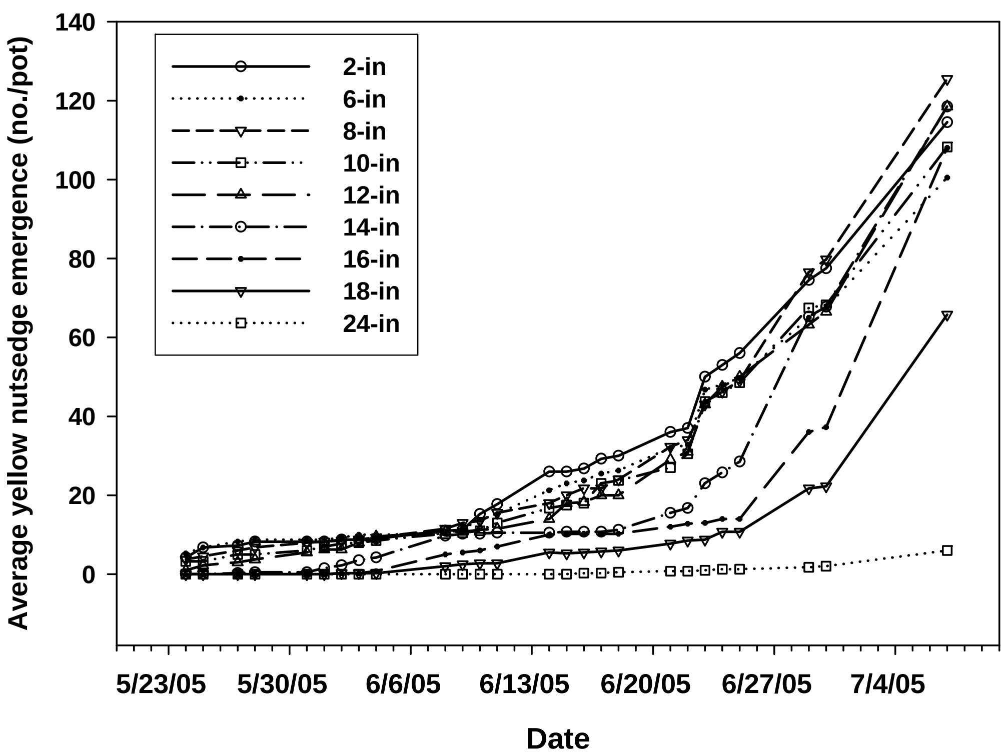

Figure 2. Yellow nutsedge shoot emergence over time as influenced by depth of germination, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Yellow nutsedge growth in response to irrigation and nitrogen fertilization

There were no significant interactions between irrigation criteria and fertilization. Nitrogen fertilization did cause a significant increase in shoot number, but not on shoot biomass, tuber number, total tuber weight per plot, or individual shoot or tuber weight (data not shown). Since there were no interactions, irrigation criteria data were averaged over fertilization levels. Irrigation events and total water applied are shown in Table 2. The number of irrigations and the total amount of water applied were much less for the -20-kPa and –50-kPa irrigation treatments compared to 2003. This may have been because temperatures were lower in 2004 compared to 2003. Soil moisture potential over time by irrigation regime is illustrated in Figure 3. Irrigation had a significant effect on yellow nutsedge shoot number and total weight (Table 3). The –20-kPa irrigation treatment produced an average of 1,747 shoots per plot. This was significantly greater than the –50-kPa and –80-kPa irrigation treatments, which produced 444 and 411 shoots per plot, respectively. All shoot numbers were much lower than in 2003. The –50-kPa and –80-kPa treatments produced similar numbers of shoots, while in 2003 the –50-kPa treatment produced almost twice as many shoots as the –80-kPa treatment. The –20-kPa irrigation treatment produced an average of 2.7 lb of shoot biomass per plot and the shoots in this treatment had higher weight per shoot than in the other irrigation treatments. Based on the digital images, the area infested by the yellow nutsedge shoots grew quickest for the –20-kPa treatment and much slower with either the –50- or –80-kPa treatments (Fig. 4). Similar to 2003, the amount of area infested was fairly small from June 4 to July 19. Over a 27-day period from July 21 to August 17 the area infested by yellow nutsedge in the –20-kPa treatments increased from 2.6 to 22.6 ft^2. Yellow nutsedge tuber production was higher with the –20-kPa irrigation criterion compared to the other irrigation criteria and total numbers for this treatment were similar to 2003 (Table 4). An average of 19,508 tubers/plot were produced from a single plant with the –20-kPa treatment. The –50- and –80-kPa treatments produced 4,447 and 5,826 tuber, respectively. The –50-kPa treatment produced 10,000 fewer tubers in 2004 than in 2003.

This year's results demonstrate that under high levels of irrigation yellow nutsedge can produce large numbers of shoots and tubers. This continues to be much higher than previously reported in the literature. However, the differences between 2003 and 2004 suggest that factors other than irrigation criteria may significantly affect the productive potential of yellow nutsedge when irrigation levels are moderate.

Table 2. Number of irrigations, amount applied per irrigation, and total water applied, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Irrigation criteria	Irrigations		Total applied*
kPa	number/plot	inches/event	inches/plot
-20	45	0.32	15.9
-50	7	1.0	8.5
-80	4	1.38	7.0

*Total includes 1.48 inch of rainfall.

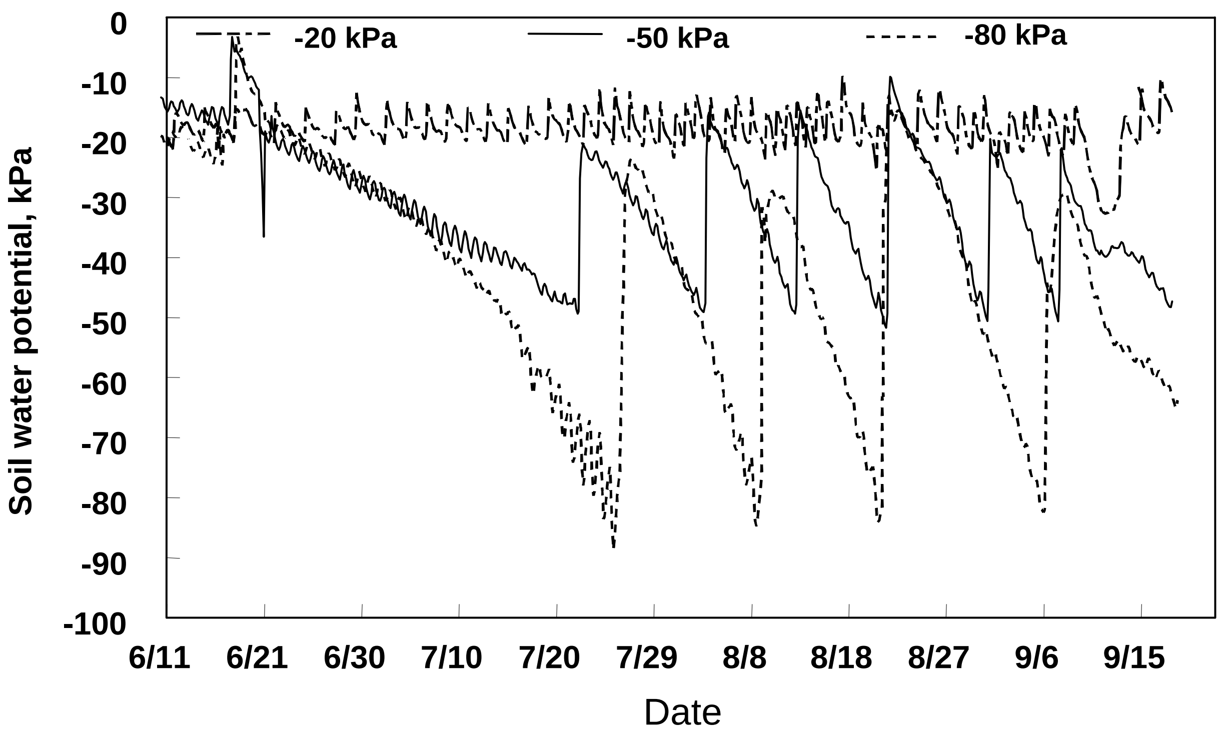

Figure 3. Soil moisture potential over time by irrigation regime, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 3. Yellow nutsedge shoot production as influenced by irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Irrigation	Yellow nutsedge shoots*				
kPa	no./plot	no./ft^2	lb/plot	lb/ft^2	g/shoot
-20	1,747 a	62 a	2.7 a	0.095 a	0.71 a
-50	444 b	16 b	0.5 b	0.019 b	0.51 b
-80	411 b	15 b	0.5 b	0.018 b	0.56 b

*Values followed by the same letter designation are not statistically different (P = 0.05).

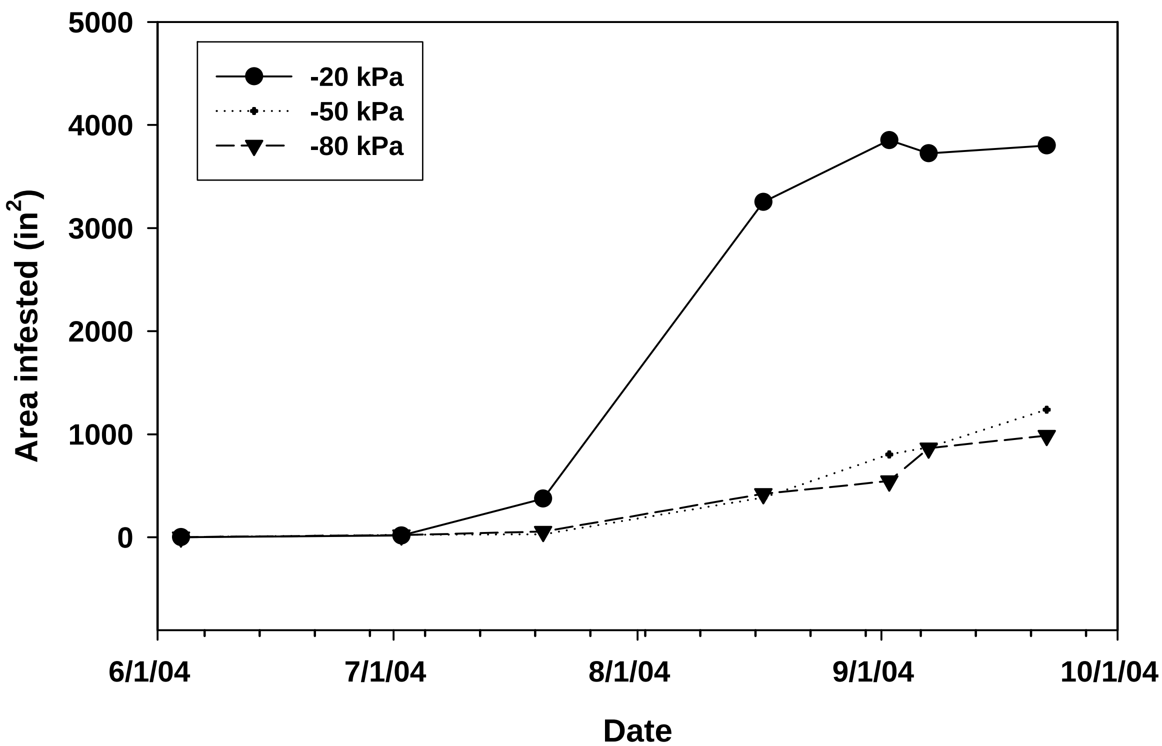

Figure 4. Yellow nutsedge patch expansion over time based on percent ground coverage between transplanting and harvest, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Table 4. Yellow nutsedge tuber production as influenced by irrigation, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Irrigation	Yellow nutsedge tubers				
kPa	no./plot	no./ft^2	lb/plot	lb/ft^2	g/tuber
-20	19,508 a	690 a	5.1 a	0.18 a	0.12 b
-50	4,447 b	157 b	1.5 b	0.005 b	0.15 a
-80	5,826 b	207 b	1.7 b	0.006 b	0.13 b

*Values followed by the same letter designation are not statistically different (P = 0.05).

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YELLOW NUTSEDGE CONTROL IN CORN AND DRY BEAN CROPS

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Introduction

Yellow nutsedge is an increasing weed problem in the Treasure Valley of eastern Oregon and southwestern Idaho. Yellow nutsedge is particularly detrimental in onion production due to the noncompetitive nature of the crop and the ability of yellow nutsedge to proliferate under the growing conditions that exist in onion production. Previous research conducted in the Treasure Valley evaluating yellow nutsedge control in onion has met with limited success, in part due to the lack of effective herbicide options and the weed's ability to germinate over long periods of time during the growing season. An integrated approach is needed to manage yellow nutsedge, including the use of effective herbicide treatments in each of the crops within a rotation. In 2003, several herbicide treatments in corn and dry bean significantly reduced the number of yellow nutsedge tubers in the soil. This research was conducted to further evaluate the effects of crop species and herbicides on growth and development of yellow nutsedge in field corn and dry bean production.

Methods

Studies were conducted in a field heavily infested with yellow nutsedge located north of Ontario on the Oregon Slope. The soil was a Owyhee silt loam with pH 8.5 and 1.7 percent organic matter. The field was disked on May 19 and ground hogged on May 20. The field was bedded for corn and dry bean on May 21 and preirrigated. Plots were 7.33 ft wide and 30 ft long and were replicated 4 times and arranged in a randomized block design. Pretreatment nutsedge tubers were sampled May 31, which consisted of taking 8 core samples measuring 4.25 inches in diameter and 7 inches deep from the center furrow within each individual plot. The samples were combined and the tubers were extracted from the soil by washing the soil through screens with 11/64-inch holes. To determine treatment effects on tuber numbers, core samples were taken again at harvest. Season-end core samples were taken from the bed tops of the center two rows in each plot. Four cores were sampled from each row. The extraction process for season-end yellow nutsedge tubers was the same as for the initial samples. In total, tuber sampling involved taking 1,280 core samples and washing tubers from approximately 3.9 tons of soil. Herbicide applications were made with a CO_2-pressurized backpack sprayer calibrated to deliver 20 gal/acre at 30 psi. Crop injury and visual evaluations of yellow nutsedge control were made throughout the growing season. Yields were taken for each crop by harvesting the center two rows of each plot.

Corn

Beds were sidedressed with 150 lbs of nitrogen (N) on May 31. The field was harrowed on June 1 and preplant incorporated (PPI) Dual ll Magnum® (s-metolachlor) treatments were applied to plots and incorporated by making two passes with the bed harrow in opposite directions. Pioneer 'P-36N69 Roundup Ready' field corn was planted on June 1 on a 7-inch seed spacing on 22-inch rows. Mid-postemergence treatments were applied June 21 and late postemergence treatments were applied on June 29. Postemergence treatments included Basagran® (bentazon), Permit® (halosulfuron), and Roundup® (glyphosate). Basagran and Roundup were applied once following PPI Dual Magnum, twice alone, or twice following PPI Dual Magnum. Permit was applied once alone and in combination with Basagran following PPI Dual Magnum. Basagran and Permit were applied in combination with a crop oil concentrate (COC) while ammonium sulfate (AMS) was added to Roundup applications. Yield was determined by harvesting ears from the center two rows of each plot on October 12. The ears were shelled, and grain moisture content and weights were recorded. Final yields were adjusted to 12 percent moisture content.

Dry Bean

On May 31, plots were sidedressed with 150 lb N/acre. On June 1, beds were harrowed, and PPI herbicide treatments were applied and incorporated by harrowing the beds twice more in opposite directions. PPI treatments included Dual Magnum® (s-metolachlor), Eptam® (EPTC), and a combination of Dual Magnum plus Eptam. Small white beans ('Aurora' variety) were planted and Prowl® (pendimethalin) was applied preemergence to help control weeds other than yellow nutsedge. On June 11, due to poor bean emergence, we decided to replant. The field was sprayed with 0.75 lb ai/acre Roundup and 2.5 lb/acre of AMS to remove the beans that had emerged. A different variety of pinto bean 'Othello' was planted on June 14.   Postemergence treatments were applied July 6 and included Sandea® (halosulfuron) plus nonionic surfactant (NIS) and Basagran plus COC. The plots treated with Basagran received a second application of Basagran on July 21. On September 16, plants were pulled from the center two rows of each plot to determine dry bean yield. After the bean plants had dried, the beans were threshed by with a Hege plot combine.

Results and Discussion

Corn

The corn rotation had some of the best yellow nutsedge control and all treatments had less tuber production compared to the untreated check (Table 1). Corn was not injured by any of the herbicide treatments evaluated. Yellow nutsedge control ranged from 68 to 97 percent on July 8 and 79 to 97 percent on July 28 (Table 1). Dual II Magnum alone and Roundup applied twice provided the least control on July 8 and Dual II Magnum provided less control than all other treatments on July 28. Treatments with herbicides applied PPI and followed by multiple postemergence (POST) applications tended to have greater yellow nutsedge control than treatments with only PPI or POST treatments. Tuber numbers increased by 55 percent in the untreated plots. In herbicide-treated plots the change in yellow nutsedge tuber numbers ranged from a 68 percent decrease to a 2 percent increase. Dual II Magnum followed by Permit plus COC resulted in significantly fewer tubers than Dual II Magnum followed by one application of Basagran plus COC. Corn yields did not differ significantly among treatments and ranged from 224 to 246 bu/acre.

Dry Bean

Dry beans also appear to have effective options for yellow nutsedge control. On the July 8 evaluation, yellow nutsedge control was significantly better with Eptam plus Dual Magnum when both were applied PPI as compared to Eptam applied PPI and Dual Magnum applied preemergence (PRE) (Table 2). On July 8, treatments with Dual Magnum applied PPI were more effective than Eptam PPI followed by Dual Magnum PRE. At this rating, POST treatments had been applied only 2 days earlier and yellow nutsedge was not exhibiting symptoms. On July 28, herbicide treatments provided 59-91 percent yellow nutsedge control. Treatments with only PPI or POST herbicides were generally less effective than combinations with a PPI application followed by one or two POST herbicide applications. Yellow nutsedge tuber numbers increased by 77 percent in the untreated plot. In the herbicide-treated plots, the change in yellow nutsedge tuber numbers ranged from a 43 percent decrease to a 7 percent increase with no significant differences between herbicide treatments. All herbicide treatments increased dry bean yield compared to the untreated check. Basagran applied twice POST had lower bean yield than Eptam plus Dual Magnum applied PPI.

Table 1. Corn yield, yellow nutsedge control, and yellow nutsedge tuber response to herbicide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

Treatment[a]	Rate	Timing[b]	Crop yield	Nutsedge control 7-8	Nutsedge control 7-28	Average nutsedge tubers Initial	Average nutsedge tubers Final	Average nutsedge tubers Change
	lb ai/acre %v/v		bu/acre	-------------%-----------		----------no/ft^2---------		---%---
Untreated control	--	--	224	--	--	148	220	55
Dual II Magnum	1.6	PPI	243	68	79	164	77	-32
Basagran + COC Basagran + COC	1.0 + 1.0 % 1.0 + 1.0%	MP LP	240	94	86	172	62	-57
Roundup + AMS Roundup + AMS	0.58 + 2.5 0.58 + 2.5	MP LP	235	69	88	193	75	-54
Dual II Magnum Basagran + COC	1.6 1.0 + 1.0%	PPI LP	236	84	89	123	78	2
Dual II Magnum Roundup + AMS	1.6 0.58 + 2.5	PPI MP	246	79	87	154	72	-49
Dual II Magnum Permit + COC	1.6 0.031 + 1.0%	PPI MP	231	83	95	238	64	-68
Dual II Magnum Basagran + Permit + COC	1.6 1.0 + 0.031 + 1.0%	PPI MP	229	97	97	260	69	-67
Dual II Magnum Roundup + AMS Roundup + AMS	1.6 0.58 + 2.5 0.58 + 2.5	PPI MP LP	245	83	92	248	89	-53
Dual II Magnum Basagran + COC Basagran + COC	1.6 1.0 + 1.0% 1.0 + 1.0%	PPI MP LP	242	96	97	199	73	-58
LSD (0.05)	--	--	NS	10	6	NS	33	59

[a]COC = crop oil concentrate, AMS = ammonium sulfate.
[b]Application timing abbreviations and dates: Preplant incorporated (PPI) on June 1, mid-postemergence (MP) on June 21, and late postemergence (LP) on June 29.

Table 2. Dry bean yield, yellow nutsedge control, and yellow nutsedge tuber response to herbicide treatments, Malheur Experiment Station, Oregon State University, Ontario, OR, 2004.

				Nutsedge control		Average nutsedge tubers		
Treatment[a]	Rate	Timing[b]	Crop yield	7/8	7/28	Initial	Final	Change
	lb ai/acre %v/v		cwt/acre	-----------%-----------		-----------no/ft^2----------		---%---
Untreated control			33	--	--	236	365	77
Dual Magnum	1.6	PPI	41	76	59	198	149	3
Eptam Dual Magnum	3.9 1.6	PPI PRE	42	40	68	352	231	-14
Eptam Dual Magnum	3.9 1.3	PPI PPI	45	78	76	218	141	-28
Dual Magnum Sandea + NIS	1.6 .031+.25%	PPI POST	44	81	91	235	172	7
Dual Magnum Sandea + Basagran + NIS	1.6 .031+ 1.0+.25%	PPI POST POST	43	73	91	271	128	-43
Basagran + COC Basagran + COC	1.0+1.0% 1.0+1.0%	POST LP	40	4	70	255	177	-24
Dual Magnum Basagran + COC	1.6 1.0+1.0%	PPI POST	43	75	85	206	155	-12
Dual Magnum Basagran + COC Basagran + COC	1.6 1.0+1.0% 1.0+1.0%	PPI POST LP	42	75	90	279	158	-20
LSD (0.05)			4	20	10	156	75	65

[a]The entire trial was treated with Prowl (1.0 lb ai/acre) preemergence for control of weeds other than yellow nutsedge. NIS = non-ionic surfactant, COC = crop oil concentrate.
[b]Application timing abbreviations and dates: Preplant incorporated (PPI) on June 1, preemergence (PRE), postemergence (POST) on July 6, and late postemergence (LP) on July 21.

CHEMICAL FALLOW FOR YELLOW NUTSEDGE SUPRESSION FOLLOWING WHEAT HARVEST

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Introduction

Yellow nutsedge is extremely competitive with onions and other crops. Few herbicide treatments are effective for managing yellow nutsedge within an onion crop. Herbicides that can be used in corn and dry bean can effectively reduce yellow nutsedge tubers in the soil. Generally, we think that yellow nutsedge does not grow well in a wheat crop because wheat is so competitive. However, following wheat harvest, yellow nutsedge shoots can be seen actively growing. Little is known about yellow nutsedge growth following wheat harvest and its potential to produce additional tubers during this time. Also, the time between wheat harvest and fall ground preparation may be a window to further reduce the yellow nutsedge population. A special registration for Eptam® in Arizona allows its use in the late summer as a fallow treatment in preparation for a winter crop. We conducted a trial to determine the number of tubers produced by yellow nutsedge following wheat harvest, and whether the use of Eptam as a chemical fallow could reduce tuber production.

Methods

A wheat field with a prior history of severe yellow nutsedge infestation was selected for this trial. Following wheat harvest, the field was corrugated and irrigated. As soon as the field was dry enough it was disked to remove yellow nutsedge shoots that had emerged and to level the field. Once the surface was dry, Eptam was applied at 7.0 pt/acre and immediately incorporated by disking to approximately 6-inch depth. The treatments compared in the trial included disking only or disking plus Eptam. The trial area was left undisturbed until bedding in the fall. Eptam was applied with a CO_2-pressurized backpack sprayer delivering 20 gal/acre at 30 psi. Plots measured 12 ft wide by 30 ft long and were replicated 4 times in a randomized complete block design. Shoot emergence was monitored by counting shoots within 1-yd^2 quadrats. Changes in tuber numbers were documented by taking 8 core samples 4.25 inches in diameter and 7 inches deep from each plot and washing the tubers from the soil. Core samples were taken prior to treatment and again at the conclusion of the trial. Initial core samples were taken August 3 and final core samples were taken October 21. In addition to sampling in the trial area, samples were taken from an area adjacent to the trial to provide observational data on the effect of disking once, disking twice, and disking twice with Eptam incorporated with the second disking.

Data were analyzed using paired t-tests at the 5 percent level (0.05).

Results and Discussion

The Eptam fallow label says that the field should not be irrigated for as long as possible to prevent the Eptam from volatilizing from the soil. The day after the Eptam treatments at least 0.5 inches of rain fell across the valley. Eptam incorporated with disking reduced yellow nutsedge shoot and tuber numbers compared to disking alone (Table 1). In plots that were disked only, tuber numbers increased by 97 percent while in plots where Eptam was incorporated with the disking, tuber numbers only increased 7 percent. When 1-ft^2 quadrats were harvested by hand in an attempt to recover tubers attached to actively growing shoots, there were significantly fewer tubers in the Eptam-treated plots compared to the disked-only plots (Table 2). The ratio of tubers in the Eptam-treated plots compared to the disked-only plots was much smaller than from the core samples. This demonstrates that the Eptam was reducing the production of new yellow nutsedge tubers, and likely inhibiting the germination of tubers that were present when the Eptam was applied. Sampling from nonreplicated strips in the field suggests that any additional management of yellow nutsedge growth decreased the total number of tubers produced. Disking once had the highest number of tubers followed by disking twice, and then by disking once and then applying Eptam and incorporating with a second disking.

This research demonstrated that significant numbers of yellow nutsedge tubers can be produced following wheat harvest. Management of yellow nutsedge growth following wheat harvest is essential to prevent the production of additional tubers and the potential buildup of tubers to levels that will make yellow nutsedge control difficult in following crops. The use of Eptam as a chemical fallow treatment significantly reduced yellow nutsedge shoot and tuber production.

Table 1. Yellow nutsedge shoot and tuber numbers in response to disking and Eptam® plus disking, Malheur Experiment Station, Ontario, OR, 2004.

Treatment	Yellow nutsedge shoots		Yellow nutsedge tubers		
	Sept. 16	Oct. 4	Initial	Final	Change
	-------------no/yd^2-------------		--------------no/ft^2----------		%
Disking only	17	23	45	79	+ 94
Eptam + Disking	7	14	45	48	+ 7

Table 2. Yellow nutsedge shoot and tuber numbers in response to disking and Eptam®, taken from hand-harvested quadrats on October 21, Malheur Experiment Station, Ontario, OR, 2004.

Treatment	Yellow nutsedge	
	Shoots	Tubers
	no/yd^2	no/ft^2
Disking only	37	33
Eptam + Disking	11	7

Table 3. Average yellow nutsedge shoot and tuber numbers in response to disking and Eptam®, taken from nonreplicated strips adjacent to the trial area on October 6, Malheur Experiment Station, Ontario, OR, 2004.

Treatment	Yellow nutsedge	
	Shoots	Tubers
	no/yd^2	no/ft^2
Disked once	60	47
Disked twice	32	20
Disked followed by Eptam + Disking	14	5

APPENDIX A. HERBICIDES AND ADJUVANTS

Trade Name	Common or Code Name	Manufacturer
Basagran	bentazon	BASF Ag Products
Betamix	desmedipham + phenmedipham	Bayer CropScience
Bronate	bromoxynil + MCPA	Bayer CropScience
Buctril	bromoxynil	Bayer CropScience
Callisto	mesotrione	Syngenta
Casoron 4G	dichlobenil	Crompton
Chateau	flumioxazin	Valent
Clarion	nicosulfuron + rimsulfuron	DuPont
Command	clomazone	FMC
Dacthal	DCPA	Syngenta
Distinct	diflufenzopyr + dicamba	BASF Ag Products
Dual, Dual Magnum, Dual II Magnum	metolachlor	Syngenta
Dyne-Amic	proprietary surfactant blend	Helena Chemical
Eptam	EPTC	Syngenta
Goal, Goal 2XL	oxyflurorfen	Dow Agrosciences
Gramoxone	paraquat dichloride	Syngenta
Karmex	diuron	Griffin LLC
Kerb	pronamide	Dow Agrosciences
Matrix	rimsulfuron	Dupont
Option	foramsulfuron	Bayer CropScience
Outlook	dimethenamid-p	BASF Ag Products
Nortron	ethofumesate	Bayer CropScience
Permit	halosulfuron	Monsanto
Poast, Poast HC	sethoxydim	BASF Ag Products
Progress	desmedipham + phenmedipham + ethofumesate	Bayer CropScience
Prowl, Prowl H_2O	pendimethalin	BASF Ag Products
Quest	proprietary spray additive	Helena Chemical
Roundup, Roundup Ultra	glyphosate	Monsanto
Sandea	halosulfuron	Gowan Company
Sencor	metribuzin	Bayer CropScience
Sinbar	terbacil	DuPont
Spartan	sulfentrazone	FMC
Stinger	clopyralid	Dow Agrosciences
Treflan	trifluralin	Dow Agrosciences
UpBeet	triflusulfuron	Dupont
Valor	flumioxazin	Valent

APPENDIX B. INSECTICIDES, FUNGICIDES, AND NEMATICIDES

Trade Name	Common or Code Name	Manufacturer
Asana	esfenvalerate	DuPont
Aza-Direct	azadirachtin	Gowan Company
Bayleton	triadimefon	Bayer CropScience
Bravo, Bravo Weather Stik	chlorothalanil	Syngenta
Captan	captan	Micro Flo
Capture	bifenthrin	FMC
Counter 20 CR, Counter 15G	terbufos	BASF Ag Products
Diazinon AG500	diazinon	Helena Chemical
Dibrom	naled	UAP
Dimethoate	dimethoate	Several
Dithane	mancozeb	Dow Agroscience
Ecozin	azadirachtin	Amvac
Gaucho	imidacloprid	Gowan Company
Guthion	azinphos-methyl	Bayer CropScience
Headline	pyraclostrobin	BASF Ag Products
Kocide	copper hydroxide	Griffin
Lannate	methomyl	DuPont
Lorsban, Lorsban 15G	chlorpyrifos	Dow Agroscience
Malathion	malathion	UAP
Messenger	harpin protein	Eden BioScience
Metasystox-R	oxydemeton-methyl	Gowan Company
MSR	oxydemeton-methyl	Gowan Company
Mustang	zeta-cypermethrin	FMC
Penncap-M	methyl parathion	Cerexagri, Inc.
Ridomil Gold MZ	metalaxyl	Syngenta
Success	spinosad	Dow Agrosci.
Super-Six	liquid sulfur	Plant Health Tech.
Telone C-17	dichloropropene + chloropicrin	Dow Agrosci.
Telone II	dichloropropene	Dow Agrosci.
Temik 15G	aldicarb	Bayer Cropscience
Thimet	phorate	BASF Ag Products
Topsin M	thiophanate-methyl	Cerexagri, Inc.
Tops-MZ	thiophanate-methyl	UAP
Vapam	metham sodium	Amvac
Vydate, Vydate L	oxamyl	DuPont
Warrior	cyhalothrin	Syngenta
Warrior T	cyhalothrin	Syngenta

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

Common names	Scientific names
alfalfa	*Medicago sativa*
barley	*Hordeum vulgare*
bluebunch wheatgrass	*Pseudoroegneria spicata*
corn	*Zea mays*
dry edible beans	*Phaseolus spp.*
Great Basin wildrye	*Leymus cinereus*
hicksii yew	*Taxus x media*
onion	*Allium cepa*
pacific yew	*Taxus brevifolia*
poplar trees, hybrid	*Populus deltoides* x *P. nigra*
potato	*Solanum tuberosum*
Russian wildrye	*Psathyrostachys juncea*
Siberian wheatgrass	*Agroyron fragile*
soybeans	*Glycine max*
spearmint, peppermint	*Mentha sp.*
sugar beet	*Beta vulgaris*
supersweet corn	*Zea mays*
sweet corn	*Zea mays*
triticale	*Triticum* x *Secale*
western yarrow	*Achillea millifolium*
wheat	*Triticum aestivum*

APPENDIX D. COMMON AND SCIENTIFIC NAMES OF WEEDS

Common names	Scientific names
annual sowthistle	*Sonchus oleraceus*
common lambsquarters	*Chenopodium album*
downy brome	*Bromus tectorum*
dodder	*Cuscuta sp.*
green foxtail	*Setaria viridis*
redroot pigweed	*Amaranthus retroflexus*
barnyardgrass	*Echinochloa crus-galli*
kochia	*Kochia scoparia*
hairy nightshade	*Solanum sarrachoides*
Powell amaranth	*Amaranthus powellii*
prickly lettuce	*Lactuca serriola*
Russian knapweed	*Acroptilon repens*
yellow nutsedge	*Cyperus esculentus*

APPENDIX E. COMMON AND SCIENTIFIC NAMES OF DISEASES AND INSECTS

Common names	Scientific names
Diseases	
onion black mold	*Aspergillus niger*
onion neck rot, (gray mold)	*Botrytis allii*
onion plate rot	*Fusarium oxysporum*
onion translucent scale	
potato late blight	*Phytophthora infestans*
Insects	
cereal leaf beetle	*Oulema melanopus*
lygus bug	*Lygus hesperus*
onion maggot	*Delia antiqua*
onion thrips	*Thrips tabaci*
pea aphid	*Acyrthosiphon pisum*
seed corn maggot	*Delia platura*
stinkbug	*Pentatomidae* sp
spidermite	*Tetranychus* sp.
sugar beet root maggot	*Tetanops myopaeformis*
willow sharpshooter	*Graphocephala confluens* (Uhler)