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June 1994

Malheur County Crop Research Annual Report, 1993

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CONTRIBUTORS
MALHEUR EXPERIMENT STATION SPECIAL REPORT
1993 RESEARCH

MALHEUR COUNTY OFFICE, OSU EXTENSION SERVICE PERSONNEL:

Jensen, Lynn	Assistant Professor
Simko, Ben	Associate Professor

MALHEUR EXPERIMENT STATION:

Barnum, Mike	Research Assistant
Feibert, Erik	Research Assistant
Ishida, Joey	Bio Sciences Research, Technician 2
Kee, Mary Jo	Office Coordinator
Saunders, Lamont	Bio Sciences Research, Technician 3
Shock, Clinton C.	Superintendent and Professor
Stanger, Charles E.	Professor of Crop Science

MALHEUR EXPERIMENT STATION, STUDENTS:

Barnum, Patrick	Research Aide
Kennington, Vanessa	Research Aide
Tolman, Nathan	Research Aide
Selfridge, Mary	Research Aide
Wickert, Brian	Research Aide

OREGON STATE UNIVERSITY, CORVALLIS, AND OTHER STATIONS:

Appleby, Arnold	Professor, Dept. of Crop Science
Baggett, James	Professor, Dept. of Horticulture
Burrill, Larry	Weed Control Specialist
English, Marshall	Professor, Dept. Bioresource Engineering
Hane, Dan	Research Assistant (Hermiston)
Holmes, Zoe Ann	Professor, Dept. of Foods and Nutrition
James, Steven	Research Assistant (Redmond)
Koepsell, Paul	Extension Plant Pathologist
Kogan, Marcos	Director, IPPC
Kolding, Mathias	Sr. Instructor (Hermiston)
Kronstad, Warren	Professor, Dept. of Crop Science
Mitchell, Alan	Assistant Professor, Central Oregon R & E Center
Mittelstadt, Bob	Graduate Student, Dept. of Bioresource Engineering
Mosley, Alvin	Associate Professor, Dept. of Crop and Soil Science
Raja, Syed Navaid	Graduate Student, Dept. of Bioresource Engineering
Richardson, Daryl	Professor, Dept. of Horticulture
Rykbost, Ken	Superintendent, Klamath Falls
Seddigh, Majid	Research Assoc., Dept. of Crop and Soil Science
Tunio, Abdul	Graduate Student, Dept. of Bioresource Engineering
Verhoeven, Mary	Instructor, Dept. of Crop Science
Zwer, Pamela	Asst. Professor, Columbia Basin Ag Research

UNIVERSITY OF IDAHO:

Brown, Bradford	Associate Professor/Extension Crop Mgmt. Specialist
Stieber, Tim	Extension Agent, USDA Hydrologic Project

OTHER PERSONNEL COOPERATING ON SPECIAL PROJECTS:

Auyer, ZaDean	Regional Economic Development Strategy
Cooper, R. L.	ARS, Wooster, OH
Corbett, Jim	Carnation, Fieldman
Derie, Lyle	Clark Seed
Frahm, Rod	Cooperating Farmer
Futter, Herb	District Conservationist, Ontario, OR
Hawkins, Al	Irrometer Co., Riverside, CA
Hobson, Joe	Hobson Manufacturing, Ontario, OR
Joplin, Carl	Mobay, Nampa, ID
Komoto, Bob	Ontario Produce
Oftedal, Steve	Cal-West Seeds
Sowokinos, Joe	Red River Valley Potato Research Lab., East Grand Forks, MN
Stubstad, John	Andrews Seed
Teramura, Ken	Cooperating Farmer
Vogt, Glenn	J.R. Simplot Co., Caldwell, ID
Weber, Charles	Weber Brothers Ranch
Wettstein, Lou	Cooperating Farmer

GROWERS ASSOCIATIONS SUPPORTING RESEARCH:

Idaho Alfalfa Seed Growers Association
Idaho-Eastern Oregon Onion Committee
Malheur County Alfalfa Seed Growers Association
Malheur County Potato Growers
Nevada Seed Council
Nyssa-Nampa Beet Growers Association
Oregon Essential Oil Growers League
Oregon Mint Growers Association
Oregon Potato Commission
Oregon Processed Vegetable Commission
Washington Alfalfa Seed Growers

OREGON PUBLIC AGENCIES SUPPORTING RESEARCH:

Department of Agriculture
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WEATHER

1993 FORAGE ALFALFA VARIETY EVALUATION RESULTS

J. Mike Barnum
Malheur Experiment Station
Oregon State University
Ontario, Oregon

Purpose

The purpose of this trial is to identify high yielding alfalfa forage cultivars adapted to conditions in the Treasure Valley. It is expected that this trial will be maintained through five harvest seasons until the fall of 1997.

Procedure

This alfalfa variety trial was established following winter wheat in the fall of 1992. The trial includes seven public and 28 proprietary alfalfa cultivars. Individual plots 5 feet wide by 22 feet long were arranged in a randomized complete block design with four replications.

In mid-September 1992, following the harvest of a wheat crop, the trial area was disked two ways and ripped two ways. Because soil test results showed very low phosphorus levels, 970 pounds of P_2O_5 and 205 pounds of N as 11-52-0 were applied to the trial area prior to final seed bed preparation. The fertilizer was incorporated into the soil profile during ensuing secondary tillage operations that included disking, rototilling, and land-planing. A preplant application of benefin (Balan DF) at 1.5 lb ai/ac in 20 gallons of water per acre was applied by ground rig and rototilled into the top 4 inches of the soil profile. The soil was bedded-up on 60-inch centers, and the beds were firmed with a rubber-tire roller. The trial was planted with a seven row disk-opener plot drill. The seed was drilled approximately one-fourth to one-half inch deep into dry soil. The seeding rate for all entries was approximately 20 pounds per acre. On September 17, three four-hour long sprinkler irrigations were applied to promote uniform rapid germination and assure stand establishment.

In mid-April 1993 two herbicide applications to control seedling broadleaf weeds and grasses were applied by ground rig. The first application, for broadleaf weeds, was a tank mix containing 0.5 lb ai/ac 2,4-DB (Butoxone) + 0.25 lb ai/ac bromoxynil (Buctril) in 20 gallons of water per acre. The second application, for emerged seedling grasses, consisted of 0.47 lb ai/ac sethoxydim (Poast) + 2 pints crop oil per acre in 20 gallons of water per acre.

Yield was collected by cutting a 3-foot wide strip through the center of each plot with a flail-type forage harvester, and then weighing the freshly cut green forage. Forage moisture content was determined by drying samples from eight randomly selected plots.

During the 1993 harvest season the trial was cut four times. Near Infrared Reflectance Spectroscopy (NIR) analysis was utilized to evaluate forage quality of each entry within one replication for the second and third cuttings. Tissue samples for the NIR analyses taken immediately prior to the second and third cuttings were collected by randomly selecting 20 mature stems from each plot within the first replication.

Results and Discussion

Some stunting of all entries was caused by the early season post-emergence herbicide applications. As a result, the first cutting for the 1993 crop year was delayed until June 14. Subsequently, the second, third, and fourth cuttings were harvested several weeks later than expected.

Yields for each entry for the 1993 crop year are reported in ranked order in tons per acre at 88 percent dry mater (DM) in Table 1. The mean 1993 season yield at 88 percent DM for the trial was 12.36 tons per acre. First year season yields ranged from 13.48 tons for Lobo to 11.57 tons per acre for PSS 393. The first season total yield for Lobo was significantly greater than the yield for ABI 9160 and those ranked below ABI 9160.

Forage quality values, reported in terms of percent acid detergent fiber (ADF) and percent crude protein (CP), derived from samples taken from one replication for the second and third cuttings, are presented in Table 2. The mean ADF over both cuttings was 30.8 percent. Analysis of ADF values over the two cuttings showed that the range from 33.9 for Lahontan to 28.6 for WL-317 was significant. The mean CP over both cuttings was 21 percent. Analysis of the CP values over the two cuttings showed that the range from 22.8 WL-320 to 19.2 Washoe was not significant. The third cutting ADF and CP values for both Washoe and Lahontan appear to be inconsistent when compared to the range of values for the other 33 entries. With Washoe and Lahontan excluded, analyses of the mean ADF and CP values showed no significant differences among the 33 remaining entries. It is suggested that the difference in ADF is due to laboratory analysis error. Additionally, some difference may be attributable to trial management. Since all entries are subjected to the same management schedule, irrigation, harvest timing, etc., it is possible that those entries that are more adapted to that schedule may respond more favorably.

Information pertaining to winter hardiness and insect and disease resistance adapted from other sources is presented in Table 3.

Table 1. First year yield of 35 alfalfa cultivars at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

		Yield by cutting and cutting date				
Cultivar	Source	1st 6/14	2nd 7/13	3rd 8/24	4th 10/12	Season Total
		------------	------------	%	------------	------------
Lobo	SeedTec Intl.	3.10	3.30	3.63	3.46	13.48
DK133	Dekalb Plant Genetics	3.19	3.21	3.54	3.23	13.16
PGI 2152	MBS, Inc.	3.07	3.05	3.45	3.50	13.07
Blazer-XL	Union Seed Co.	3.05	3.31	3.22	3.35	12.93
Archer	ABI Alfalfa	2.83	3.26	3.33	3.49	12.91
5683	Pioneer HiBred Intl.	2.94	3.12	3.29	3.36	12.71
Garst 630	ICI Americas	3.04	3.06	3.42	3.18	12.70
AP 8950	ABI Alfalfa	2.76	3.18	3.42	3.33	12.68
1-A	Candy Co.	2.90	3.23	3.22	3.32	12.67
Achieva	Allied Seed Co-op	3.25	3.06	3.26	3.08	12.65
Excalibur II	Allied Seed Co-op	3.00	3.03	3.51	3.08	12.62
Asset	Allied Seed Co-op	3.01	3.17	3.21	3.16	12.55
Crystal	MBS, Inc.	3.00	3.17	3.18	3.19	12.53
Lahontan	Public	2.95	3.22	3.19	3.16	12.52
Wrangler	Public	2.91	3.18	3.32	3.04	12.45
ABI 9151	ABI Alfalfa	2.92	3.05	3.25	3.17	12.39
Sutter	MBS, Inc.	2.77	3.05	3.25	3.32	12.39
WL 317	W-L Research	2.97	3.06	3.15	3.15	12.33
ABI 9160	ABI Alfalfa	2.99	2.83	3.16	3.30	12.27
Hyland	Oasis Seed	2.69	3.13	3.32	3.12	12.26
WL 323	W-L Research	3.11	2.88	3.32	2.94	12.24
5472	Pioneer HiBred Intl.	2.68	3.14	3.32	3.06	12.21
WL 320	W-L Research	2.53	3.08	3.26	3.30	12.17
1-T-11	Candy Co.	2.76	2.99	3.36	3.07	12.17
Maxi-Leaf	Ray Brothers Seed	3.13	2.99	3.14	2.92	12.17
3 J 15	Union Seed Co.	2.83	2.96	3.41	2.92	12.12
CUF-101	Public	2.58	2.81	3.28	3.37	12.04
WL 322 HQ	W-L Research	2.55	2.88	3.36	3.07	11.86
89-30	W-L Research	2.93	2.90	3.01	3.01	11.85
Future	Ray Brothers Seed	2.65	3.02	3.16	3.00	11.82
Washoe	Public	2.83	2.94	3.17	2.89	11.82
5364	Pioneer HiBred Intl.	2.61	3.06	3.16	2.94	11.77
Vernema	Public	2.73	3.20	2.95	2.85	11.72
Perry	Public	3.01	3.05	2.95	2.71	11.71
PSS 393	Price & Sons, Inc.	3.00	2.93	2.92	2.72	11.57
Mean		2.89	3.07	3.26	3.14	12.36
LSD (0.05)		0.47	0.48	0.32	0.40	1.20
C.V.		11.6%	11.1%	7.2%	9.2%	7.0%

[*] Yields at 88 percent dry matter

Table 2. Percent acid detergent fiber (ADF) and percent crude protein (CP) for the second and third cuttings from one replication of 35 alfalfa cultivars at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Cutting and cutting date					
	2nd (7/13)		3rd (8/24)		Mean	
Cultivar	ADF	CP	ADF	CP	ADF	CP
			%			
Lobo	30.58	22.93	31.53	18.40	31.06	20.67
DK133	29.64	24.21	30.13	20.65	29.89	22.43
PGI 2152	32.51	21.13	32.16	18.98	32.34	20.06
Blazer-XL	33.54	21.21	31.51	18.30	32.53	19.76
Archer	29.26	23.74	33.87	18.80	31.57	21.27
5683	31.79	21.73	32.02	18.39	31.91	20.06
Garst 630	30.80	22.66	29.29	19.59	30.05	21.13
AP 8950	26.63	25.59	32.67	18.74	29.65	22.17
1-A	33.90	20.08	30.10	20.03	32.00	20.06
Achieva	32.22	21.61	31.45	18.69	31.84	20.15
4 J 19	28.80	24.16	29.43	20.38	29.12	22.27
Asset	31.63	21.69	30.25	19.73	30.94	20.71
Crystal	30.74	22.77	30.27	19.05	30.51	20.91
Lahontan	31.57	22.63	36.29	16.26	33.93	19.45
Wrangler	30.93	22.18	27.33	21.59	29.13	21.89
ABI 9151	27.67	23.66	32.26	17.85	29.97	20.76
Sutter	30.09	22.36	31.53	18.10	30.81	20.23
WL 317	26.70	25.37	30.57	18.79	28.64	22.08
ABI 9160	28.80	24.27	30.66	19.50	29.73	21.89
Hyland	32.54	21.17	32.09	18.75	32.32	19.96
WL 323	28.79	24.16	31.86	19.28	30.33	21.72
5472	29.83	22.72	33.50	17.90	31.67	20.31
WL 320	26.93	25.55	31.75	20.10	29.34	22.83
1-T-11	30.56	22.64	29.78	19.89	30.17	21.27
Maxi-Leaf	29.97	22.96	30.80	19.76	30.39	21.36
3 J 15	29.64	23.55	27.95	21.16	28.80	22.36
CUF-101	31.06	21.77	33.07	17.97	32.07	19.87
WL 322	27.92	25.45	32.30	19.14	30.11	22.30
89-30	29.96	23.72	31.48	19.67	30.72	21.70
Future	31.49	22.83	30.54	20.28	31.02	21.56
Washoe	29.82	22.75	36.94	15.65	33.38	19.20
5364	30.49	23.02	32.20	18.48	31.35	20.75
Vernema	31.63	22.14	29.64	19.43	30.64	20.79
Perry	29.97	23.26	29.11	20.85	29.54	22.06
PSS 393	32.19	21.22	29.63	19.92	30.91	20.57
Mean	30.30	22.94	31.31	19.14	30.81	21.04
LSD (0.05)					4.21	NS
CV					6.74	14.00

Table 3. Disease and insect resistance levels for the 35 alfalfa cultivars included in the 1993 alfalfa forage evaluation trial at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

Cultivar	Source	Year of release to public	Pathogen or Insect										
			FD	BW	FW	VW	PRR	AN	DM	PA	SAA	RKN	SN
Perry*	USDA/U.Neb	1979	3	R	R	S	MR	LR	MR	R	MR	-	-
Wrangler*	USDA/U.Neb	1983	2	R	R	LR	HR	LR	R	HR	HR	-	-
Vernema*	USDA/WSU	1981	4	MR	-	MR	LR	LR	-	-	MR	-	HR
PSS 393	Price & Sons	(nr)	6.5	-	-	-	-	-	-	-	-	-	-
Washoe*	USDA/UNV	1965	5	R	-	-	R	LR	S	R	R	-	R
Lahontan*	USDA/UNV	1954	6	MR	LR	S	LR	-	S	LR	MR	S	R
CUF-101*	USDA/UC	1976	9	-	HR	-	MR	-	LR	HR	HR	MR	LR
1-A	Candy Co.	1992	3	-	-	-	-	-	-	-	-	-	-
1-T-11	Candy Co.	1992	5	-	-	-	-	-	-	-	-	-	-
Asset*	Allied Seed	1990	4	HR	R	R	HR	R	-	R	R	-	-
Achieva*	Allied Seed	1992	3	HR	HR	R	HR	HR	-	-	-	-	MR
Hyland*	Oasis Seed	1993	3	HR	HR	R	HR	R	-	HR	R	-	R
Garst 630	ICI Americas	1985	4	HR	R	MR	R	MR	-	R	MR	-	R
Maxi-Leaf	Ray Brothers	1993	5.5	R	MR	LR	R	R	-	-	-	-	-
Future	Ray Brothers	1987	5.6	HR	MR	MR	R	LR	-	-	MR	-	MR
DK 133*	Dekalb Plant Genetics	1991	4	HR	HR	R	HR	HR	-	R	R	-	MR
Blazer-XL	Union Seed	1991	3	R	HR	R	HR	HR	-	R	HR	-	R
3-J-15	Union Seed	(nr)	3	HR	HR	R	HR	HR	-	R	HR	-	R
Excalibur II	Allied Seed	1993	4	HR	HR	R	HR	HR	-	R	HR	-	R
Lobo*	SeedTec	1991	6	MR	HR	MR	R	HR	-	R	HR	R	R
Crystal*	PGI/MBS	1990	4	HR	HR	R	HR	R	-	R	LR	-	MR
Sutter*	PGI/MBS	1987	7	R	HR	LR	HR	LR	-	R	HR	-	R
PGI 2152	PGI/MBS	1992	5	HR	HR	R	R	R	-	R	HR	-	MR
5472*	Pioneer Hi-Bred	1989	4	HR	HR	MR	MR	MR	-	HR	R	-	R
5364*	Pioneer Hi-Bred	1989	4	R	R	MR	MR	MR	-	HR	HR	-	R
5683*	Pioneer Hi-Bred	1988	7	MR	R	S	R	S	-	R	HR	-	R
WL 317*	WL Research	1988	3	HR	HR	R	HR	R	-	HR	HR	MR	R
WL 320*	WL Research	1985	4	R	HR	MR	R	MR	-	R	R	-	MR
WL 322 HQ*	WL Research	1991	4	HR	HR	R	R	MR	-	HR	HR	LR	LR
89-30	WL Research	(nr)	4	HR	HR	HR	HR	HR	-	R	MR	-	MR
WL 323	WL Research	1993	3	HR	HR	R	HR	HR	-	R	MR	-	R
AP 8950	ABI	(nr)	4	MR	HR	MR	R	MR	-	HR	HR	R	R
ABI 9160	ABI	(nr)	5	MR	MR	MR	R	-	-	R	R	R	R
ABI 9151	ABI	(nr)	5	MR	HR	MR	R	MR	-	-	-	-	MR
Archer	ABI	1988	5	MR	HR	LR	R	MR	-	-	-	-	MR

* Information confirmed by the National Alfalfa Variety Review Board.
(nr) Not released or no release date available.

FD = Fall Dormancy, BW = Bacterial Wilt, FW = Fusarium Wilt, VW = Verticillium Wilt, PRR = Phytophthora Root Rot, AN = Anthracnose, DM = Downy Mildew, PA = Pea Aphid, SAA = Spotted Alfalfa Aphid, RKN = Root Knot Nematode, SN = Stem Nematode.

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

Disease and Insect Resistance: 51% = HR (Highly Resistant), 31-50% = R (Resistant), 15-30% = MR (Moderately Resistant). 6-14% = LR (Low Resistance), 5% = S (Susceptible)

ANNUAL WEED CONTROL IN SPRING SEEDED ALFALFA WITH POSTEMERGENCE HERBICIDES APPLIED TO SEEDLING ALFALFA WITH TWO OR THREE TRIFOLIATE LEAVES

Charles E. Stanger and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Purpose

To compare herbicides applied postemergence at different rates and tank-mixes for tolerance of seedling alfalfa and control of annual broadleaf and grassy species of weeds.

Procedures

Seed of Wrangler alfalfa was planted on April 30, in rows spaced 22 inches apart. Alfalfa seed was planted using Gandy granular insecticide applicators mounted on a Beck sugar beet or onion planting unit. The seeded alfalfa was watered by furrow irrigation for seed germination and emergence on May 1.

The postemergence herbicide treatments were applied on May 31. The seedling alfalfa was about 3 inches tall with two and three sets of trifoliate leaves. Herbicides applied included Pursuit, Buctril, 2, 4-DB Amine, and Basagran. Pursuit was evaluated as a 2 pound emulsifiable concentrate and a 70 DG formulation. Activity of both formulations were compared with Uran, Sunlit II, and X-77 as additives. Select herbicide was evaluated for grass control when tank-mixed with certain treatments of Pursuit and Pursuit + Buctril tank-mix combinations. Weed species present when herbicides were applied included redroot pigweed, lambsquarters, purslane, hairy nightshade, tansy mustard, witchgrass, barnyardgrass, and green foxtail. Broadleaf weeds were 2-4 inches tall, and purslane had stem runners 3-4 inches long. The tallest grasses had 4-5 leaves with one tiller.

The herbicides were applied using a single-bicycle wheel plot sprayer equipped with a 7.5 foot four-nozzle boom. Spray nozzles were teejet fan nozzles size 8002. A nozzle was centered over each row when spraying. Individual plot size was four rows wide and 25 feet long. Each treatment was replicated three times using a randomized block experimental design. Spray pressure was 42 psi and water was applied at a volume of 19.5 gallons/acre. Soil texture was silt loam, with 1.3 percent organic matter and a pH of 7.3.

The treatments were evaluated on June 11 and June 20 for crop injury and weed control. All ratings were by visual evaluation with 0 equaling no herbicide effect and 100 equaling all plants killed. Injury ratings above 50 indicate stand reductions occurring with one percent stand reduction for each percent increase in crop injury rating above 50. Ratings less than 50 indicated stunting but no stand reduction with the crop recovering and resuming normal growth with no final reduction in foliar growth compared to alfalfa growth in untreated check plots.

Results

The best treatment for weed control and crop tolerance was the tank-mix combination of Buctril, Pursuit, and Select applied at 16 + 3 + 24 fl oz of product per acre. This combination treatment gave 100 percent control of all broadleaf and grassy weeds with the least amount of crop injury. Both the dry granular and the emulsifiable concentrate formulation of Pursuit controlled all redroot pigweed, shepherds purse, and purslane, but did not control lambsquarters or the grass species. Sunit II added to all combinations including Pursuit and Basagran/2,4-DB Amine tank-mix increased herbicide activity resulting in severe injury to seedling alfalfa. Seedling alfalfa was more tolerant to Pursuit/Uran tank-mixed with X-77 than with Sunit II. Both weed control and crop tolerance was better with the Basagran/Pursuit combination than the Basagran/2,4-DB Amine combination. Sunit II added to Basagran/2,4-DB Amine probably caused the excessive injury to the seedling alfalfa. Select herbicide added to Pursuit/Surfactant combination, and Buctril/Pursuit was compatible in tank-mixes and gave 100 percent control of the grass species.

Table 1. Percent crop injury and weed control from herbicides applied postemergence to seedling alfalfa with three or four sets of trifoliate leaves. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

					Weed control																							
		Crop Injury			Pigweed			Lambsquarters			Purslane			Hairy Nightshade			Shepherd Purse			Witchgrass			Green foxtail			Barnyardgrass		
Herbicides	Rate	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	fl oz of product/ac	- - - % - - -			%																							
Pursuit + Uran + X-77	3 + 32 + 0.25%	20	10	10	100	100	100	50	60	60	100	100	100	80	85	80	100	100	100	90	80	85	80	75	80	75	80	75
Pursuit 70DG + Uran + X-77	1.05 + 32 + 0.25%	20	10	10	100	100	100	70	80	70	100	100	100	75	80	85	100	100	100	85	90	85	75	70	70	80	70	80
Pursuit + Uran + X-77	4 + 32 0.25%	20	10	10	100	100	100	92	95	95	100	100	100	90	85	85	100	100	100	85	90	90	80	85	80	85	85	80
Pursuit + Uran + X-77	6 + 32 + 0.25%	20	20	20	100	100	100	95	90	95	100	100	100	98	95	98	100	100	100	80	85	80	90	90	90	90	95	90
Pursuit + Uran + Sunit II	3 + 32 + 24	20	25	25	100	100	100	65	65	65	100	100	100	75	80	80	100	100	100	85	85	80	85	85	80	90	80	85
Pursuit 70DG + Uran + Sunit II	1.05 + 32 + 24	40	40	40	100	100	100	80	65	65	100	100	100	70	80	75	100	100	100	80	90	85	70	75	70	80	75	80
Pursuit 70DG Uran + Sunit II	2.10 + 32 + 24	45	50	50	100	100	100	80	85	80	100	100	100	85	80	80	100	100	100	90	80	85	80	85	80	80	80	85
Pursuit + Uran + Sunit II	4 + 32 + 24	35	35	35	100	100	100	85	85	80	100	100	100	95	90	90	100	100	100	90	90	90	85	80	85	85	85	80
Pursuit + Uran + Sunit II	6 + 32 + 24	60	65	70	100	100	100	85	80	85	100	100	100	98	98	98	100	100	100	95	95	95	90	90	85	95	85	85
Select + Uran + Sunit II	6 + 32 + 24	5	0	0	50	50	40	10	10	10	0	0	0	0	10	10	10	15	15	100	100	100	100	100	100	100	100	100
Pursuit + Select + Uran + Sunit II	4 + 6 + 32 + 24	40	25	30	100	100	100	80	85	80	100	100	100	95	90	85	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Pursuit + Select	16 + 3 + 6	10	10	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2, 4-DB Amine	32	12	12	12	80	85	80	95	95	95	100	100	100	65	60	60	50	65	65	0	0	0	0	0	0	0	0	0
2, 4-DB Amine Basagran + Sunit II	16 + 32 + 24	65	60	65	80	85	85	90	85	85	75	85	80	80	85	85	80	80	80	10	10	10	0	0	0	0	0	0
Basagran + Pursuit + Sunit II	32 + 3 + 24	30	20	20	100	100	100	100	95	90	100	100	100	100	100	100	100	100	100	70	75	70	70	70	70	75	70	70
Untreated Check	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1. Information:

-Pursuit EC = fl oz/ac of 2 lb/gal formulation
-Pursuit 70DG = oz/ac of 70% dry
-Uran = all applied at 1 qt of 28-0-0/ac
-Sunit II = all applied at 1.5 pts/ac of formulated product
-Buctril, Basagran and 2, 4-DB rate expressed in fl/oz of 2, 4 and 4 lb/gal formulations respectively

WEED CONTROL IN MINT CROPS

Charles E. Stanger and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Introduction

Approximately 75 percent of the peppermint and spearmint acreage in Malheur County of eastern Oregon and southwest Idaho is watered by furrow irrigation. Because of furrow irrigation, herbicide application to new and established stands of peppermint and spearmint are timed to be activated by either natural moisture or mechanical tillage, or timed as postemergence treatments. Applying residual herbicides with both soil and foliar activity in the fall and early spring is popular among mint growers because soil activity of herbicides is enhanced by water from rain and snow during late fall, winter, and early spring. Herbicides applied with postemergence activity are applied to control perennial and annual broadleaf grassy weeds that germinate and grow in the winter and summer, or have escaped previously applied herbicide treatment.

Purpose

Command (clomozone) and Karmex (diuron) herbicides were evaluated for crop tolerance and weed control in spearmint and peppermint. Weed species include blue mustard (Chorispora tenella), prickly lettuce (Lactuna serriola), kochia (Kochia scoparia), lambsquarters (Chenopodium album), redroot pigweed (Amaranthus retroflexus), cheeseweed (Malva neglecta), barnyardgrass (Enchinochloa crus-galli), and green foxtail (Setaria viridus), which are common winter and summer annual weeds occurring in these crops.

Procedures

Herbicides were applied as single and tank-mix combinations as fall and spring applied treatments to established stands of peppermint and spearmint. Trials were conducted off-station in grower fields. Herbicides used in single tank-mixes with Karmex included Sinbar, Prowl, Sonolan, Stinger, and Buctril. Prowl and Stinger were tank-mixed with Command applied on November 11 and 18, 1992. Karmex and Karmex tank-mix combinations were applied on March 31 and April 28, 1993. Herbicide rates and tank-mix combinations are listed in tables 1, 2, 3, 4, and 5.

Weed species varied between location sites at each trial and are included in the data tables. Soil textures varied from clay to sandy loam; organic matter from 0.85 to 1.3 percent, and soil pH from 6.8 to 7.6. Spearmint at Stuart Batt's farm was sprinkler irrigated. Peppermint was furrow irrigated at Mio Farms and at Froerer Farms. Air temperatures, soil temperatures (4-inch depth), wind velocity, soil moisture, and other environmental conditions when herbicides were applied are included with data tables.

All treatments were replicated three times at each location. Individual plot size was 9x30 feet. Herbicides were sprayed as broadcast double overlap applications using teejet nozzles, size 8002. Spray pressure was 42 psi, and water as the herbicide carrier was applied at a volume of 32 gallons/acre. Spearmint from trials located at Stuart Batt's was harvested from all treatments to determine both hay and oil yields. Three subplot samples were harvested from each plot. Hay from each subsample was cut from a 16 square foot area. Harvested hay was weighed, and 10 pounds of the hay was taken from each subplot sample, air dried, and distilled to determine oil yield.

Results

Both spearmint and peppermint were tolerant to Command and Karmex herbicides applied alone and in tank-mix combination with Sinbar, Stinger, Buctril, Goal, Prowl, and Sonalan. Leaf chlorosis was noted with Command, but the symptoms were only short-lived and did not inhibit normal growth or final hay or oil yields. Command and Karmex gave excellent control of mustard weed species. When activated by rain they persisted in the soil to control germinating kochia, pigweed, and lambsquarters, which emerged later in the untreated check plots. Tank-mixes of Command or Karmex with Stinger or Sinbar gave particularly good control of prickly lettuce, marestail, salisfy, seedling mallow, and summer annual grasses. Refer to data tables for weed control and crop tolerance rating for each herbicide treatment.

Hay and oil yields of spearmint harvested from plots were not reduced by the application of Command or Karmex herbicides, applied singly or in tank-mix combinations, when plot yields were compared to yields sampled from the grower's field. Hay and oil yields were reduced significantly by weed competition in the untreated checks (Tables 6 and 7).

Table 1. Percent weed control and crop tolerance from herbicides applied in the spring to established peppermint at Fruitland, Idaho. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Percent weed control																							
		Crop injury			Barnyardgrass			Blue mustard			Green foxtail			Kochia			Lambsquarters			Prickly lettuce			Pigweed		
Herbicide	Rate	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	-- lbs ai/ac --	---- % ----			%																				
Command	0.5	0	0	0	85	85	88	100	100	100	90	90	93	100	100	100	100	100	100	80	85	80	98	95	95
Command	1.0	0	0	0	93	90	93	100	100	100	95	90	95	100	100	100	100	100	100	98	95	95	100	100	100
Command + Stinger	0.5 + 0.125	0	0	0	80	85	90	100	100	100	90	88	90	100	100	100	100	100	100	100	100	100	95	95	98
Command + Stinger	1.0 + 0.125	0	0	0	90	93	93	100	100	100	95	95	95	100	100	100	100	100	100	100	100	100	99	99	99
Command + Stinger + Prowl	0.5 + 0.125 + 2	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Command + Stinger + Prowl	1.0 + 0.125 + 2	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Command + Stinger + Sonalan	0.5 + 0.125 + 1.5	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Command + Stinger + Sonalan	1.0 + 0.125 + 1.5	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Stinger + Prowl	0.75 + 0.125 + 2	0	0	0	95	98	98	95	98	98	98	95	95	95	95	95	95	95	95	100	100	100	95	98	95
Check	-	35	40	45	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Ratings indicate reduction in growth of mint because of weed competition. Evaluated May 15. Herbicides applied November 18, 1992. Soil texture - silt loam. Soil Organic matter - 1.2 percent. Ratings 0 = no herbicide injury, 100 = all plants killed. Ph 7.1. Peppermint dormant when sprayed. Grower - Ron Mio.

Table 2. Percent weed control and crop tolerance from herbicides applied in the spring to established spearmint at Ontario, Oregon. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment					Percent Weed Control																	
		Crop Injury			Blue mustard			Prickly lettuce			Salisfy			Tumbling mustard			Pigweed			Green foxtail		
Herbicide	Rate	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	----- lbs ai/ac ----	---- % ----			%																	
Command	0.5	0	0	0	100	100	100	80	75	80	65	70	70	100	100	100	95	98	95	80	80	85
Command	1.0	0	0	0	100	100	100	95	95	98	75	80	80	100	100	100	99	100	99	90	95	90
Command + Stinger	0.5 + 0.125	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	85	75	80
Command + Stinger	1.0 + 0.125	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	95	90	95	90	85	90
Command + Stinger + Prowl	0.5 + 0.125 + 2	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	98	99	98	100	100	100
Command + Stinger + Prowl	1.0 + 0.125 + 2	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Command + Stinger + Sonolan	0.5 + 0.125 + 1.5	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Command + Stinger + Sonolan	1.0 + 0.125 + 1.5	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Stinger + Prowl	0.75 + 0.125 + 2	0	0	0	95	95	98	100	100	100	93	95	93	93	93	98	95	90	95	95	98	95
Check	-	25	30	35	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Ratings indicate reduction in growth of mint because of weed competition. Evaluated May 15. Herbicides applied November 11, 1992. Spearmint was dormant. Soil texture - clay loam, 1.1 percent organic matter and Ph 6.9. Ratings 0 = no

Table 3. Percent weed control and crop injury ratings for herbicides applied to established spearmint at Ontario, Oregon. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Percent weed control																				
		Crop injury			Blue mustard			Tumbling mustard			Prickly lettuce			Kochia			Pigweed			Green foxtail		
Herbicide	Rate	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	lbs ai/ac	--- % ---			%																	
Karmex	0.8	0	0	0	100	100	100	100	100	100	85	80	80	95	95	90	98	95	95	93	95	90
Karmex + Sinbar	0.8 + 1.0	0	0	0	100	100	100	100	100	100	95	98	95	98	95	95	98	98	98	98	95	95
Karmex + Sonolan	0.8 + 1.5	0	0	0	100	100	100	100	100	100	95	95	98	100	100	100	100	100	100	100	100	100
Karmex + Prowl	0.8 + 2	0	0	0	100	100	100	100	100	100	98	95	95	100	100	100	100	100	100	100	100	100
Karmex + Command	0.8 + 0.5	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Karmex + Stinger	0.8 + 0.125	0	0	0	100	100	100	100	100	100	100	100	100	95	95	95	98	95	98	95	90	95
Karmex + Buctril	0.8 + 0.5	0	0	0	100	100	100	100	100	100	99	98	98	90	95	90	90	85	90	95	90	95
Buctril + Goal	0.25 + 0.1	0	0	0	95	95	95	98	99	98	95	95	95	90	90	85	85	95	90	65	60	65
Buctril + Goal	0.15 + 0.05	0	0	0	90	93	90	95	93	95	93	90	95	95	90	95	95	90	95	60	50	60
Buctril + Goal + Karmex	0.15 + 0.5 + 0.8	0	0	0	100	100	100	100	100	100	100	100	100	98	98	98	98	98	98	95	95	93
Check[1]	-	4	30	30	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Ratings indicate reduction in mint growth because of weed competition. Evaluated May 15. Ratings 0 = no herbicide injury, 100 = all plants killed. Soil texture - clay loam, 1.1 percent organic matter and Ph 6.9. Herbicide applied March 30, 1993. Spearmint had started spring growth with newly emerged shoots about one inch tall. Grower - Stuart Batt.

Table 4. Percent weed control and crop injury ratings for herbicides applied to established peppermint at Nyssa, Oregon, Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Percent weed control																				
		Crop injury			Blue mustard			Green foxtail			Prickly lettuce			Mallow[1]			Pigweed			Kochia		
Herbicide	Rate	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	lbs ai/ac	%																				
Karmex	0.8	0	0	0	100	100	100	95	85	90	90	80	80	85	90	90	100	100	100	98	100	98
Karmex + Sinbar	0.8 + 1.0	0	0	0	100	100	100	98	96	98	100	100	100	100	100	100	100	100	100	100	100	100
Karmex + Sonolan	0.8 + 1.5	0	0	0	100	100	100	100	100	100	90	85	80	90	85	85	100	100	100	100	100	100
Karmex + Sonolan + Stinger	0.8 + 1.5 + 0.125	0	0	0	100	100	100	100	100	100	100	100	100	90	85	85	100	100	100	100	100	100
Karmex + Command	0.8 + 0.5	10	15	10	100	100	100	100	100	100	85	90	90	90	85	85	100	100	100	100	100	100
Karmex + Command + Stinger	0.8 + 0.5 + 0.125	15	10	15	100	100	100	100	100	100	100	100	100	95	90	90	100	100	100	100	100	100
Karmex + Stinger	0.8 + 0.125	0	0	0	100	100	100	90	85	90	100	100	100	98	95	95	100	100	100	100	100	100
Buctril + Goal	0.15 + 0.05	0	0	0	90	95	90	35	30	25	85	90	85	60	70	70	85	75	70	70	70	65
Buctril + Goal	0.25 + 0.1	5	5	5	95	95	95	35	35	30	85	90	90	75	80	75	85	80	80	75	80	75
Buctril + Goal + Sinbar	0.25 + 0.1 + 0.5	0	0	0	95	98	95	80	75	75	95	98	95	95	85	90	95	90	90	75	70	70
Buctril + Goal + Karmex	0.25 + 0.1 + 0.8	5	0	5	100	100	100	90	85	85	95	98	98	95	95	98	100	100	100	100	100	100
Karmex + Dual	0.8 + 3.0	0	0	0	100	100	100	95	98	95	95	93	98	90	95	90	100	100	100	100	100	100
Check[1]	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Seedling mallow. Evaluated May 15. Ratings 0 = no herbicide injury, 100 = all plants killed. Soil texture - silt loam, 1.0 percent organic matter and Ph 6.8. Herbicides applied March 31, 1993. Peppermint had started spring growth. The new buds were red and leaves hadn't appeared. Grower - Froerer Farms.

Clark Ave. Nyssa, Froerer Farms -Soil Texture, silt loam -Soil O. Matter, 1.3% -Soil pH, 7.6

Table 5. Percent weed control and crop injury ratings for herbicides applied to established spearmint at Nyssa, Oregon. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Crop injury			Percent weed control																	
					Blue mustard			Downy brome$^{(1)}$			Kochia			Prickly lettuce			Pigweed			Tumbling mustard		
Herbicide	Rate	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	lbs ai/ac	%																				
Buctril + Stinger	0.25 + 0.125	0	0	0	70	65	65	100	100	100	90	85	85	100	100	100	85	90	85	75	75	70
Buctril + Stinger	0.5 + 0.125	0	0	0	85	80	80	100	100	100	90	90	90	100	100	100	90	85	90	85	80	85
Buctril + Stinger	0.75 + 0.125	0	0	0	90	90	85	100	100	100	95	90	90	100	100	100	90	90	90	90	80	85
Buctril + Diuron	0.25 + 0.8	0	0	0	100	100	100	100	100	100	99	98	98	98	95	98	100	100	100	100	100	100
Buctril + Diuron	0.5 + 0.8	0	0	0	100	100	100	100	100	100	99	100	99	99	98	98	100	100	100	100	100	100
Buctril + Goal	0.15 + 0.05	0	0	0	75	80	80	100	100	100	90	85	90	85	85	80	75	85	85	85	80	85
Buctril + Sinbar	0.5 + 1.0	0	0	0	85	85	80	100	100	100	90	85	85	95	95	90	90	85	85	95	95	90
Check	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Added Fusilade + activated crop oil to all treatments at the rate of 0.1875 lbs ai/ac and 1 qt/ac respectively. Evaluated May 15. Ratings 0 = no herbicide injury, 100 = all plants killed.

Columbia Ave. Nyssa, Froerer Farms -Soil texture, loam -Soil O. matter, 1.3% -Soil Ph, 6.8

Table 6. Fresh hay and oil yields of spearmint harvested from plots treated with Karmex and other herbicides applied as tank-mixes. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Herbicide	Rate	Fresh hay weights		Oil yields
	lbs ai/ac	lbs/ac	tons/ac	lbs/ac
Karmex	0.8	28,161	14.08	97.16
Karmex + Sinbar	0.8 + 1.0	29,649	14.82	103.87
Karmex + Prowl	0.8 + 2.0	30,488	15.42	93.25
Karmex + Sonolan	0.8 + 1.5	29,082	14.54	89.95
Karmex + Stinger	0.8 + 0.125	31,650	15.83	87.17
Karmex + Command	0.8 + 0.5	28,742	14.37	86.06
Karmex + Dual	0.8 + 3.0	29,071	14.54	89.98
Command	0.5	29,651	14.83	103.85
Command + Stinger + Karmex	0.05 + 0.125 + 0.8	29,023	14.51	87.84
Buctril + Goal	0.05 + 0.15	28,160	14.08	97.26
Karmex + Goal + Buctril	0.8 + 0.05 + 0.15	29,664	14.73	97.45
Check	-	24,381	12.19	68.0
Mean		29,001	14.50	91.65
LSD (0.05)		3,510	1.76	17.21
CV %		7.2	7.2	6.8

Table 7. Percent weed control and crop injury ratings for herbicides applied to established spearmint at Ontario, Oregon. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment					Percent weed control																	
		Crop injury			Blue mustard			Tumbling lettuce			Prickly lettuce			Kochia			Pigweed			Green Foxtail		
Herbicide	Rate	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	lbs ai/ac	%																				
Karmex	0.8	0	0	0	100	100	100	100	100	100	80	78	85	90	90	93	90	95	90	90	85	90
Karmex + Sinbar	0.8 + 1.0	0	0	0	100	100	100	100	100	100	95	95	98	93	95	90	98	95	95	98	98	95
Karmex + Prowl	0.8 + 2.0	0	0	0	100	100	100	100	100	100	95	90	90	100	100	100	100	100	100	100	100	100
Karmex + Sonolan	0.8 + 1.5	0	0	0	100	100	100	100	100	100	90	95	90	100	100	100	100	100	100	100	100	100
Karmex + Stinger	0.8 + 0.125	0	0	0	100	100	100	100	100	100	100	100	100	93	90	95	95	90	95	85	90	90
Karmex + Command	0.8 + 0.5	10	10	15	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Karmex + Dual	0.8 + 3.0	0	0	0	100	100	100	100	100	100	85	90	85	100	100	100	100	100	100	100	100	100
Command	0.5	15	15	10	100	100	100	100	98	100	80	75	75	100	100	100	95	98	95	85	90	90
Command + Stinger + Karmex	0.05 + 0.125 + 0.8	15	10	15	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal	0.15 + 0.05	0	0	0	98	98	95	98	95	98	85	85	85	85	80	80	80	80	85	50	60	65
Karmex + Goal + Buctril	0.8 + 0.05 + 0.15	5	5	0	100	100	100	100	100	100	100	100	100	98	95	98	98	98	95	90	85	90
Check	---	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Stuart Batt Farms. Herbicides applied March 30th. Soil texture (clay loam), soil OM (1.1), soil Ph (6.9).

ONION VARIETY TRIALS

Charles E. Stanger and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Purpose

A trial was conducted to evaluate commercial and experimental lines of different varieties of yellow, white, and red onions for bulb yield and quality. A second trial compared topped bulbs for storage quality when stored for approximately 65 days in air-ventilated storage.

Procedures

The onions were planted on April 30 in an Owyhee silt loam soil containing 1.2 percent organic matter and with a pH of 7.3. Sugar beets and wheat had been grown in the field during 1991 and 1992, respectively. The wheat stubble was shredded and the field deep-chiseled, disced, irrigated, and moldboard-plowed in the fall. One-hundred pounds per acre of P_2O_5, and 60 pounds per acre of N were broadcast before plowing. After plowing the field was bedded and left until spring without further tillage.

Ninety-three different varieties of onions were planted in plots four rows wide and 27 feet long. The onions were planted on 22-inch single row beds. Each variety was planted in five replications. Seed for each row was prepackaged using enough seed for a planting rate of 12 viable seeds per foot of row. Seed was planted using 12-inch diameter cone-seeders mounted on a John Deere Model 71 flexi-planter unit equipped with disc openers.

The onions were furrow irrigated during the growing season. The first irrigation was applied just after planting on April 31 to supply the soil with moisture for seed germination, and seedling emergence and growth.

On May 27 through May 29 the seedling onion plants were thinned by hand to a plant population of four plants per linear foot of row (3-inch spacing between individual onion plants). Two hundred and ten pounds of N per acre as NH_4SO_4 were sidedressed on June 8. Nitrogen was shanked on each side of every row. On June 27 lay-bye herbicides were applied and the onions were cultivated for the final time. Karate insecticide was applied at two-week intervals during June, July, and August for thrip control.

Bulb maturity ratings for each plot were taken on September 3, 10, and 20. Maturity ratings were recorded as percent of growing bulbs, with leaves collapsed and laying on the ground.

The onion bulbs were lifted on September 23 and field dried for seven days. Onion bulbs from all rows of each four-row plot were hand-topped and put in burlap bags. The bagged onions were put in field storage boxes (4 x 4 x 6 feet) and left in the field for further air drying until October 11. On this date the boxes were placed in a storage facility equipped with a forced air ventilation system. The storage boxes were stacked four high, and air was directed under each storage box.

The onion bulbs were removed from storage and graded from November 16 through December 12. Bulbs were graded according to their diameter. Size categories were 2¼-3 inch, 3-4 inch, and 4 inch and larger. Split bulbs were graded as No. 2's. Bulbs infected by Botrytis neckrot were weighed and percent neckrot occurring during storage was calculated. The neckrot data is reported as an average over the five replications of hand-topped onions.

Results

Onion lines were received and evaluated from 15 seed companies. Companies include American Takii, Aristogenes, Asgrow, Crookham, Ferry Morse, Golden Valley, Abbott & Cobb, Dakota Seeds, Harris Moran, Petoseed, Rio Colorado, Scott Seeds, Shamrock, Seedex, and Sunseeds. A total of 93 lines were evaluated. Each variety and its performance data is reported in Table 1. Varieties are listed by company in alphabetical order and according to rank by total yield of bulbs for all 93 varieties entered in the trial. Bulb maturity at harvest and number of bolting plants are also reported in Table 1. All pests were controlled and were not a negating factor in varietal performance. The data reflects an accurate assessment of varietal performance in commercial field production. Differences in maturity dates occurred between onion lines, but tops were much greener this year when topped and placed in burlap bags, and severe rot occurred to onion bulbs during storage.

Average bulb yields were 806 cwt/ac with 43 percent colossal sized bulbs, 50 percent jumbo's, and 3.4 percent No. 2's. Average neckrot for all varieties was 58.3 percent.

Statistical data are included in the tables and should be considered when comparisons are made between varieties for yield and quality performance potential. Differences equal to or greater than LSD values should exist before one variety is considered superior to another.

Table 1. Yield and quality of commercial and experimental onion cultivars evaluated in 1993 variety trials. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

		Total yield		Neckrot topped	Yield by market grade								Maturity ratings			Bolting
					+ 4		3-4 inch		2¼-3 inch		No. 2's		9/3	9/10	9/20	
Company	Variety	Rank	cwt/ac	%	cwt	%	cwt	%	cwt	%	cwt	%				
Abbott and Cobb	El Charro	2	979	61.9	582	59	384	39	12	1.2	2	0.2	0	5	15	32
	Ole	15	918	79.1	606	66	260	28	11	1.2	41	4.3	0	0	7	14
	El Rey	44	829	48.8	335	40	447	54	25	3.1	22	2.6	10	25	65	3
	El Padre	56	798	72.9	317	39	454	57	21	2.7	6	0.7	0	10	15	25
	Big Red	91	586	32.2	82	14	443	76	39	6.9	22	3.7	20	35	70	0.5
American Takii	9002	29	871	58.8	474	54	370	42	16	1.9	11	1.3	0	0	5	0.5
	6404	41	837	36.7	557	66	257	31	13	1.6	10	1.2	5	15	60	0
Aristogene	AX-1514	5	938	67.8	535	57	382	41	11	1.1	9	1.0	5	15	30	23
	Seville	10	927	65.6	471	51	432	47	13	1.4	10	1.1	0	0	15	50
	Bravo	16	908	78.5	498	55	386	42	12	1.3	12	1.4	0	0	10	45
	AX-1507	18	903	69.9	480	53	394	44	15	1.6	15	1.6	0	0	8	38
	AX-3102	40	837	57.9	360	43	445	53	18	2.1	14	1.7	0	5	8	33
	AX-1688	45	823	72.8	391	47	405	49	16	1.9	13	1.5	0	0	5	50
	AX-1618	53	801	75.6	382	47	388	49	21	2.6	11	1.4	0	0	15	33
Asgrow	Riviera	4	942	46.0	524	56	374	40	20	2.2	23	2.4	35	40	80	0.5
	Vega	8	932	62.4	460	49	441	47	18	1.9	14	1.6	5	15	55	20
	XPH-3803	11	926	46.4	500	54	388	42	15	1.6	24	2.5	15	25	75	3
	XPH-3326	13	925	49.4	506	55	396	43	12	1.2	12	1.2	15	25	55	22
	XPH-3804	14	923	50.2	449	49	441	48	12	1.3	21	2.2	35	60	80	2
	XPH-3375	21	899	47.0	456	51	408	45	18	2.0	17	1.9	45	65	80	1
	XPH-3466	22	898	48.0	432	48	434	48	15	1.6	17	1.9	20	35	80	1
	Cache	27	876	46.0	439	50	393	45	18	2.1	25	2.9	30	40	80	1
	Armada	30	861	56.7	406	47	404	47	17	1.9	35	4.0	10	10	30	15
	XPH-3468	60	791	43.1	338	43	418	53	16	2.0	19	2.4	35	45	80	0.5
Crookham	Sweet Perfection	31	858	77.0	443	52	361	42	18	2.1	36	4.1	5	10	55	5
	Dai Maru	33	853	71.6	360	42	445	52	21	2.5	27	3.2	0	0	8	20
	Sweet Amber	35	850	63.8	373	44	391	46	21	2.4	66	7.7	0	5	30	20
	Ringmaker	37	846	57.9	376	44	383	45	20	2.3	67	7.8	5	5	55	8
	XPH-92373	73	711	68.3	216	30	409	58	33	4.6	53	7.5	0	0	20	15
	XPH-92378	74	710	66.7	239	34	393	55	36	5.0	42	5.9	0	0	25	22
	White Delight	93	509	67.3	208	41	229	45	18	3.6	54	10.4	0	5	5	0.2
Dakota Seed	Cody	3	947	44.9	457	48	432	46	20	2.2	37	3.9	30	50	70	8
	Cherokee	23	892	72.3	435	49	391	44	18	2.0	48	5.3	0	0	20	22
	Dakota B-11	46	823	71.0	407	49	375	46	20	2.5	21	2.6	0	0	10	22
	Aztec	48	820	69.5	369	45	380	46	24	2.9	47	5.6	0	0	15	20
	Cuzco	49	820	63.7	364	44	405	49	16	1.9	35	4.3	0	0	15	4
	Grande Gold	58	794	56.4	333	42	387	49	27	3.4	47	5.8	5	10	55	2
	Cheyenne	66	758	67.2	278	37	392	52	33	4.4	56	7.3	0	5	15	5
	Seneca	70	727	83.3	322	44	341	47	19	2.6	46	6.3	0	0	5	18
	Mohegan	71	723	14.4	328	45	351	49	25	3.5	18	2.5	45	80	95	0
	Dakota	72	712	41.8	195	27	461	65	29	4.1	27	3.8	5	5	28	3
	Zuni	77	703	75.3	203	29	447	64	38	5.4	16	2.2	0	5	30	3

Table one continued on next page.

Table 1. (continued)

		Total yield		Neckrot topped	Yield by market grade								Maturity ratings			Bolting
					+ 4		3-4 inch		2¼-3 inch		No. 2's		9/3	9/10	9/20	
Company	Variety	Rank	cwt/ac	%	cwt	%	cwt	%	cwt	%	cwt	%				
Dakota Seed (cont)	Mojave	83	679	66.4	192	28	427	63	37	5.5	23	3.4	0	0	30	3
	Zapotec	86	651	68.5	180	28	374	58	37	5.7	60	9.0	5	5	30	1
Ferry Morse	FMX-320W6	36	846	69.4	425	50	396	47	16	1.9	10	1.1	5	5	15	25
	FMX-282W6	42	834	68.0	420	50	384	46	19	2.3	11	1.3	0	5	10	15
	Oro Grande	43	834	70.1	395	47	405	49	19	2.3	16	1.9	0	0	15	30
	FMX-263W20	64	768	56.8	267	35	442	58	26	3.5	32	4.2	0	0	15	24
	Redman	78	703	31.5	205	29	410	58	34	4.9	55	7.7	40	65	90	0.5
Golden Valley	Navaho	7	933	60.4	486	52	387	42	20	2.1	40	4.2	0	10	30	3
	Laguna	34	852	71.3	422	49	388	46	16	1.9	26	3.1	5	5	18	5
	Hybrid-B	51	810	67.3	367	45	383	47	27	3.3	33	4.0	0	5	35	2
	Iroquois	52	806	70.4	376	47	352	44	30	3.6	49	6.0	5	15	45	5
	GVX-92618	55	798	73.4	371	46	366	46	22	2.8	40	5.0	0	0	4	40
	GVX-92616	61	789	60.2	322	41	397	51	37	4.6	33	4.2	5	10	23	20
	Maricopa	63	773	49.3	253	33	448	58	27	3.6	44	5.8	10	25	70	3
	GVX-92617	67	751	75.6	349	46	357	48	17	2.3	28	3.7	0	0	5	33
	GVX-92619	68	750	48.9	289	38	387	52	33	4.4	42	5.6	5	10	20	7
	GVX-92702	80	698	34.0	212	30	399	57	27	4.0	60	8.5	20	30	70	0.3
	Hopi	82	686	65.4	212	31	412	60	27	4.0	34	5.0	0	0	10	10
	GVX-92615	87	639	29.8	117	18	449	70	58	9.0	15	2.3	40	70	90	1
Harris Moran	HMX-0628	24	890	45.9	385	43	465	53	13	1.9	27	3.0	45	80	90	1
	HMX-3630	75	709	72.2	287	41	375	53	28	4.0	18	2.5	2	15	25	10
	HMX-0627	81	687	34.8	157	22	467	68	52	7.7	11	1.6	25	60	80	2
	HMX-9623	85	655	42.6	136	21	466	71	41	6.4	12	1.9	15	35	65	9
	Target	90	608	57.8	144	23	384	64	25	4.2	54	9.1	0	0	5	10
	White Ivory	92	559	35.7	58	10	380	68	63	11.4	59	10.4	15	25	75	0.5
INTA	Valcatorce	88	638	50.1	110	17	428	67	38	6.0	62	10.0	5	5	10	0.2
Nippon Norin	Tenshin	65	765	31.6	178	23	562	74	23	3.0	2	0.3	35	60	95	0
Petoseed	Atlas	12	926	73.5	545	58	364	40	14	1.5	5	0.5	7	15	30	20
	Pinnacle	17	905	48.6	473	52	417	46	11	1.2	3	0.3	10	20	60	3
	Shasta	19	901	61.2	517	57	365	41	14	1.6	5	0.5	0	15	45	3
	PSR-74089	20	899	43.8	478	53	396	44	14	1.6	11	1.3	0	0	10	14
	Apex	39	840	54.6	396	47	407	48	16	1.9	21	2.6	5	30	45	2
	Fuego	76	703	44.2	252	36	420	60	18	2.5	13	1.8	5	20	40	0.5
Rio Colorado	RNX-1068	28	874	63.9	460	53	364	42	19	2.1	32	3.6	10	20	45	18
	RCS-60102	47	822	57.1	375	45	422	52	21	2.6	4	0.5	50	60	85	1
	RCS-6077	54	798	66.9	362	45	344	43	26	3.3	66	8.2	5	5	12	22
Scottseeds	Great Scott	25	880	77.9	460	52	374	42	13	1.5	33	3.7	0	5	40	40
Shamrock	Mammoth	38	845	70.9	437	52	391	46	13	1.6	5	0.6	5	10	10	30
	Monarch	50	811	67.9	353	43	408	50	26	3.3	24	3.0	0	0	5	40
	Omega	84	655	13.0	115	17	455	70	59	9.0	26	4.0	45	85	93	1.5
Sunseeds	Sunre 1472	1	1006	68.6	594	59	396	39	11	1.1	6	0.6	8	10	60	3
	Winner	6	933	65.8	526	56	384	41	16	1.7	7	0.7	15	20	45	18
	Vaquero	9	927	68.7	493	53	415	45	17	1.8	2	0.2	0	0	7	4
	Sunre 1464	26	877	51.3	332	38	519	59	19	2.1	7	0.7	20	20	70	12

Table one continued on next page.

Table 1. (continued)

		Total yield		Neckrot	Yield by market grade								Maturity ratings			Bolting
				topped	+ 4		3-4 inch		2¼-3 inch		No. 2's		9/3	9/10	9/20	
Company	Variety	Rank	cwt/ac	%	cwt	%	cwt	%	cwt	%	cwt	%				
Sunseeds (cont)	Golden Cascade	32	857	38.8	430	50	395	46	15	1.9	17	1.8	35	50	80	2
	Valiant	57	795	54.1	374	47	384	48	32	4.1	5	0.6	5	5	35	18
	Bullring	59	792	38.5	330	42	424	54	34	4.3	4	0.4	5	5	35	15
	Valdez	62	776	74.8	372	47	366	47	27	3.6	11	1.4	5	5	15	20
	Mambo	69	749	47.0	261	35	432	58	20	2.6	37	5.0	5	15	45	0.5
	Blanco Duro	79	701	78.0	236	34	417	60	25	3.6	23	3.2	0	0	7	9
	Snow White	89	626	80.2	194	31	348	56	31	5.0	53	8.4	0	0	10	7
Mean			806	58.3	357	43	400	50	23	3.1	26	3.4	-	-	-	-
LSD .05			61	14.8	57	5	39	5	11	1.5	16	2.0	-	-	-	-
CV (%)			2.7	9.1	5.8	4.0	3.5	3	17	18	22	21	-	-	-	-

[1] Average number of bulbs with seed stalks. (Counts from 1,400 bulbs)

WEED CONTROL AND CROP TOLERANCE OF ONIONS TO HERBICIDES APPLIED AS PREPLANT, POSTEMERGENCE TO SEEDLING ONIONS, AND AS LAYBYE APPLICATIONS

Charles E. Stanger and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Introduction

Reducing production costs by improving weed control with herbicides to eliminate hand-labor for weed removal is essential to maintaining a viable onion industry. To produce maximum yields of quality bulbs, onion fields must remain weed-free until the crop is harvested. Onions are poor plant competitors and weeds can germinate and grow in onions at all times during the growing season. To control weeds effectively while the crop is growing, both soil residual and foliar active herbicides must be used to have a successful weed control program. Trials in this study were initiated to continue selecting for optimum herbicide treatments to identify effective rates and timing of application that result in complete weed control without causing injury to the growing crop. This information is needed to develop a weed-free environment in onions.

Procedures

Prowl and Sonalan at 2.0 and 1.5 lbs ai/ac respectively, were applied in two separate methods of application to compare each for control of weeds emerging after the last cultivation. One treatment was applied in the furrow area of bedded land before the beds were harrowed in preparation for planting. The second, and separate, treatment was delayed and applied across the width of the water furrows between rows just before the second irrigation following the last cultivation. The soil in the furrows was firmed and stabilized by the first watering after the last cultivation, preventing soil movement during irrigation after the herbicides were applied.

After the herbicides were applied in the furrow areas of the bedded land, the beds were harrowed and seed of Valdez onions were planted. Weeds emerging in the onion rows of laybye trials were controlled with band-applied repeat postemergence applications of a tank-mix containing Buctril, Nortron, and Poast herbicides. Prowl at 1.5 lbs ai/ac was mixed with the first application of the postemergence treatments applied to onions when the flag leaf was fully developed. The herbicides applied as preplant treatments to bedded ground were evaluated for crop injury during emergence. All treatments were evaluated for onion injury and weed control at the end of the growing season before harvest. The onions were planted on 22-inch centers and watered by furrow irrigation.

Herbicides applied in the postemergence trials included two- and three-way tank-mixes of Buctril, Nortron, Goal, Dual, Prowl, Stinger, and Poast. To evaluate onion tolerance to herbicides, the first application in separate trials was begun when the onions were in the full flag, or one-true leaf stage of growth. Additional applications were applied at about two week intervals as new weeds emerged. The first application was applied to full-flag leaf onions on May 27 and to one-leaf onions on June 4. Herbicide rates for Buctril, Goal, Nortron, Prowl, Dual, Stinger, and Poast were 0.1 and 0.15, 0.025 and 0.05, 0.25 and 0.5, 1.5 and 2.0, 2.0 and 3.0, 0.05, and 0.1 lbs ai/acre, respectively. Buctril, Goal, Norton, and Poast were applied three times. Prowl, Dual, and Stinger were applied one time and were tank-mixed with the herbicides applied in the first application of the postemergence band-applied herbicide treatments. The plots were four onion rows wide and 25 feet long. Each treatment was replicated three times using a RCB experimental design. Treatments were rated for weed control and crop tolerance one week following the last application. Weed species included dense populations of redroot pigweed, lambsquarters, kochia, hairy nightshade, volunteer potatoes, barnyardgrass, and green foxtail. To control late emerging weeds in the water furrows, Prowl at 1.5 lbs ai/ac was band-sprayed just before the second irrigation following the last cultivation.

In a separate study to evaluate for onion tolerance, Dual herbicide was applied as broadcast applications to three- and four-leaf onions at rates of 0, 1.0, 2.0, 3.0, and 4.0 lbs ai/ac. Water furrows were cultivated before herbicide application, and the onions were irrigated in furrows between each onion row the same day just after the Dual herbicide treatments were applied. The herbicides were applied as replicated (3) treatments. Each plot was eight rows wide and 50 feet long. Rating for onion tolerance was taken at two, four, and six week intervals following application and at time of harvest. Bulbs were harvested from the two center rows of each plot to determine yield of bulbs for size and quality. All herbicide treatments were applied using a single bicycle-wheel plot sprayer with a 7.5 foot boom with spray nozzles spaced 22 inches apart. The boom was shifted so nozzles were centered over rows during band-applied postemergence applications and centered in the furrow for in-furrow and laybye applied herbicide treatments. Nozzles were Teejet size 8002. Spray pressure was 42 psi and water volume applied was 19.5 gallons/acre. Refer to tables for specific environmental, crop, and weed conditions when herbicide treatments were applied.

Results

Injury did not occur from either Prowl or Sonalan applied in the furrow of bedded land or at laybye time. Both timings of herbicide application resulted in complete weed control in the furrow area through harvest. Refer to Table 1.

Flag leaf onions were tolerant to Buctril and Nortron applied in tank-mix combinations. Flag leaf onions were tolerant to Prowl, Sonalan, and the 2 lb ai/ac of Dual tank-mixed with Buctril and Nortron. Dual at 3 lbs ai/ac caused onion injury when applied to flag leaf onions because of the amount of rain (2.5 inches) received after application. Although slight and short-lived, some injury was noted from Goal when tank-mixed with Buctril and applied to flag leaf onions. Excellent control of lambsquarters, sow thistle, hairy nightshade, barnyardgrass, and green foxtail was obtained with all treatments. Some pigweed escaped Buctril alone, but was controlled effectively when

Buctril was tankmixed with Nortron. Nortron also appeared to have good herbicidal activity on volunteer potatoes. Poast tank-mixed with all herbicides controlled barnyardgrass and green foxtail. Refer to Table 2.

One-leaf onions were tolerant to Goal + Buctril tankmixes. Prowl added to Goal and Buctril gave improved control of red root pigweed from postemergence activity. One-leaf onions were more tolerant to Dual than flag leaf onions. Weed control was excellent with all treatments. A few pigweed plants did escape Buctril and Goal, but were controlled by Nortron added to the Buctril + Goal combination. As in the flag leaf trials, Nortron had good activity on volunteer potatoes. One-leaf onions were less tolerant of Dual at 4.0 lbs compared to Dual applied at the 2 and 3 lb ai/ac rate. Poast added to the tankmixes at 0.1 lb ai/ac and applied in each application controlled all barnyardgrass and green foxtail. Refer to Table 4.

BASF treatments of Poast added to Buctril, Goal, and Buctril + Goal tankmix controlled barnyardgrass, green foxtail, and witchgrass in all combinations. Some broadleaf weeds did escape Goal, but were controlled by Goal + Buctril tankmixes at rates used in this trial even though the broadleaf weeds were large because the first application was delayed until the onions were in the late one- and early two-leaf stage of growth. Refer to Table 5.

Three- and four-leaf onions were tolerant to Dual applied as a broadcast application at rates of 1.0, 2.0, 3.0, and 4.0 lbs ai/ac and activated by furrow irrigation after application. Bulb size, weight, or quality was not affected when treated bulbs were compared to bulbs from untreated weed free plots for yield of Numbers 2's, Medium (2 1/4 - 3 inch), Jumbo's (3-4 inch), and Colossal (4 inch) size bulbs. Foliar injury to onions was never noted during the growing season. Refer to Table 2.

Table 1. Percent weed control and crop tolerance of bulb onions to treatments applied preplant in-furrow to bedded land and to treatments applied at onion laybye. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment			Crop injury				Percent weed control																							
							Pigweed				Lambsquarters				Hairy nightshade				Kochia				Barnyardgrass				Green foxtail			
Herbicide	Rate	Applied	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A
	lbs ai/ac		%																											
Prowl	2.0	Preplant	0	0	0	0	100	100	100	100	100	100	100	100	93	90	95	92	100	100	100	100	100	100	100	100	100	100	100	100
		Laybye	0	0	0	0	100	100	100	100	100	100	100	100	90	95	95	93	100	100	100	100	100	100	100	100	100	100	100	100
Sonalan	1.5	Preplant	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
		Laybye	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Check		Preplant	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
		Laybye	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

1) Preplant bedded treatments applied on April 30. Harrowed beds on May 1 and planted May 2. Sprayed 11 inch band in furrow area of bedded land.

2) Laybye treatments applied July 9. Last cultivation July 2. Irrigated after cultivation on July 3. Watered in furrows between each onion row July 10. Herbicides applied in 11 inch band over center of furrow. Onions free of weeds in all areas when herbicides applied from sequential postemergence application of Buctril, Norton, and Poast.

Table 2. Onion tolerance ratings and final bulb yields from Dual herbicide applied as broadcast applications to seedling onions with four or five leaves. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Crop injury				Valdez variety market grade								
Herbicide	Rate	1	2	3	A	Number 2's		2 1/4 - 3 inch		3 - 4 inch		> 4 inch		Total
	lbs ai/ac	- - - % - - -				cwt/ac	%	cwt/ac	%	cwt/ac	%	cwt/ac	%	cwt/ac
Dual	1	0	0	0	0	26	3	48	5	276	29	586	63	936
Dual	2	0	0	0	0	23	2	52	6	254	28	594	64	923
Dual	3	0	0	0	0	25	3	46	5	269	29	575	63	915
Dual	4	0	0	0	0	24	3	52	6	261	28	595	64	932
Check	0	0	0	0	0	25	3	50	5	258	28	579	63	912
Mean						25	-	50	-	264	-	586	-	923
LSD (0.05)						3.5 (ns)	-	6.4 (ns)	-	24 (ns)	-	32 (ns)	-	36 (ns)
CV(%)						11.8	-	9.2	-	7.6	-	5.4	-	4.6

Visual ratings 6 weeks after application of herbicide treatments. Ratings: 0 = no herbicide effect.

Table 3. Percent weed control and crop tolerance ratings from herbicides applied as repeat postemergence applications to seedling onions beginning when onions had full flag leaf. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Crop injury				V. Potatoes				Lambsquarters				Hairy nightshade				Pigweed				Sow thistle				Barnyardgrass				Green foxtail			
Herbicide	Rate	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A
	lbs ai/ac	%																															
Buctril + Nortron	0.10 + 0.25	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	99	99	98	98	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Nortron	0.15 +0.25	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Nortron + Prowl	0.10 + 0.25 + 1.5	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Nortron + Sonalan	0.10 + 0.25 + 1.0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	99	98	95	97	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Dual	0.15 + 2.0	5	15	15	12	20	20	20	20	100	100	100	100	100	100	100	100	60	60	60	60	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Dual	0.15 + 3.0	50	50	50	50	40	40	40	40	100	100	100	100	100	100	100	100	80	85	80	82	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Nortron + Dual	0.10 + 0.25 + 2	30	20	20	23	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril	0.15	0	0	0	0	40	30	20	30	100	100	100	100	100	100	100	100	75	65	60	66	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Prowl	0.15 + 1.5	0	0	0	0	20	20	20	20	100	100	100	100	100	100	100	100	98	98	98	98	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal	0.10 + 0.025	10	10	0	7	70	60	60	63	100	100	100	100	100	100	100	100	85	90	80	88	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Prowl	0.10 + 0.025 + 1.0	5	0	10	5	60	65	60	62	100	100	100	100	100	100	100	100	96	98	80	91	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Sonalan	0.10 + 0.025 + 1.0	0	0	0	0	60	40	40	47	100	100	100	100	100	100	100	100	65	70	50	62	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Prowl	0.075 + 0.025 + 1.5	10	0	5	5	70	60	60	62	100	100	100	100	100	100	100	100	92	95	95	93	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Stinger + Prowl	0.15 + 0.05 + 1.5	15	20	25	20	90	80	70	80	100	100	100	100	100	100	100	100	90	90	95	92	100	100	100	100	100	100	100	100	100	100	100	100
Check	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Onions received 3 applications of herbicide treatments applied on May 27, June 7, and June 14. Prowl, Dual, and Sonalan were tank-mixed with other herbicides as listed in treatment and applied during the first application on May 27.
Poast herbicide applied to all treatments, each application at rate of 0.1 lbs ai/ac.
Evaluated on June 25. Ratings: 0 = no herbicide effect, 100 = all plants killed.

<u>Spray conditions:</u>

May 27	June 10	June 14
wind 0 - 3 mph west	wind 2 - 4 mph NW	wind calm
skies clear	skies partly cloudy	skies overcast
humidity 32%	humidity 30 %	humidity 38%
air temp. 85°F	air temp 86°F	air temp. 81° F
soil temp 4"depth 74°F	soil temp 4" depth 76°F	soil temp 4" depth 75°F

Table 4. Percent weed control and crop tolerance ratings from herbicides applied to seedling onions as repeat applications beginning when onions had one true leaf. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Crop Injury				Percent weed control																											
						V. Potatoes				Lambsquarters				Hairy nightshade				Pigweed				Sow thistle				Barnyardgrass				Green foxtail			
Herbicide	Rate	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A
	lbs ai/ac	%																															
Buctril + Goal	0.15 + 0.05	0	0	0	0	65	65	65	65	100	100	100	100	100	100	100	100	95	100	100	98	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Prowl	0.15 + 0.05 + 1.5	5	5	5	5	75	75	75	75	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Sonalan	0.15 + 0.05 + 1.0	5	5	5	5	65	65	65	65	100	100	100	100	100	100	100	100	98	98	100	98	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Sonalan	0.15 + 0.05 + 2.0	0	0	0	0	60	65	65	63	100	100	100	100	100	100	100	100	100	98	98	98	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Dual	0.15 + 0.05 + 3.0	5	5	10	7	65	70	65	67	100	100	100	100	100	100	100	100	98	98	98	98	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Nortron	0.15 + 0.05 + 0.5	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Nortron + Prowl	0.15 + 0.05 + 0.5	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Nortron + Sonalan	0.15 + 0.05 + 0.5 + 1.0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Nortron + Dual	0.15 + 0.05 + 0.5 + 2.0	0	5	5	3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Nortron + Dual	0.15 + 0.05 + 0.5 + 3.0	10	10	10	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Nortron + Dual	0.15 + 0.05 + 0.5 + 4.0	25	15	15	18	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Prowl + Dual	0.15 + 0.05 + 1.5 + 2.0	0	5	5	3	60	75	65	67	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal + Sonalan + Dual	0.15 + 0.05 + 1.0 + 2.0	0	0	0	0	65	65	65	65	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Buctril + Goal	0.2 + 0.1	5	5	5	5	65	65	60	63	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Check	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Poast herbicide tank mixed and applied with all treatments at rate of 0.1 lb ai/ac.
Onions received 3 applications of herbicide treatments applied on June 4, June 16, and June 28. Prowl, Dual, and Sonalan were tank-mixed with other herbicides as listed in treatment and only applied once during the first application on June 4.

Evaluated on July 10. Ratings: 0 = no herbicide effect, 100 = all plants killed.

Spray Conditions:

June 4	June 16	June 28
wind calm	wind 1-2 mph SW	wind 2-4 mph NW
skies partly cloudy	skies cloudy	skies partly cloudy
humidity 34%	humidity 38%	humidity 36%
air temp 84°F	air temp 76°F	air temp 85°F
soil temp 4" depth 73oF	soil temp 4" depth 71°F	soil temp 4" depth 76°F

Table 5. Percent weed control and corp injury ratings from BASF herbicide treatments applied postemergence to one true-leaf seedling onions. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Crop Injury			Percent weed control																	
					Pigweed			Lambsquarters			Hairy nightshade			Barnyardgrass			G. Foxtail			Witchgrass		
Herbicides	Rate	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	lbs ai/ac	--- % ---			%																	
Poast + Goal	0.1 + 0.05	0	0	0	100	100	95	90	93	90	95	98	95	100	100	100	100	100	100	100	100	100
Poast + Goal	0.1 + 0.09	0	0	0	100	100	100	90	93	90	95	98	95	100	100	100	100	100	100	100	100	100
Poast + Buctril	0.1 + 0.15	0	0	0	100	90	90	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Poast + Buctril	0.1 + 0.2	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Poast + Goal + Buctril	0.1 + 0.05 + 0.15	5	5	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Untreated check	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Application information:
June 4. Applied first application to onions. Onions had one true leaf with the true leaf equal or longer in length to the flag leaf. Broadleaf weeds ranged in size from cotyledon leaf to plants 3-4 inches tall. Grasses ranged from 2 leaf to plants with 1 to 3 tillers. Soil moist at surface following 3/4" of rain the last two days. Wind was calm, humidity 72%, air temp (68°F), skies cloudy with more rain forecast for next several days, soil temp (64°F).

June 12. Applied second application - Onions had two true leaves. Weeds emerged when first application was applied were dead or very severely burned. Newly emerged weeds were small - (cotyledon to 2 true leaves with largest about 1 inch tall). Air temp. (74°F), soil temp. (66°F), soil moisture 80%, humidity 52%, wind calm, skies partly cloudy.

Other applications were applied on June 19 and June 27 to control weeds until laybye herbicides were activated.

Spray information:
Plots were 4 rows wide and 25 feet long. Treatments were replicated 3 times.
Spryer was single wheel bicycle plot sprayer with a 4 nozzle boom. One nozzle was centered over each row.
Nozzles were teejet fan size 6502. Spray pressure was 42 psi. Water volume was 19.6 gal/ac.
Final evaluations for weed control and crop tolerance was made on July 9.

A COMPARISON OF SPRINKLER, SUBSURFACE DRIP, AND FURROW IRRIGATION OF ONIONS

Erik Feibert, Clint Shock, and Monty Saunders
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Introduction

Onions need to be maintained at a high soil water potential (wet soil) for optimum yields and quality. Wet soil could require the application of large amounts of irrigation water. Furrow irrigation can result in low water use efficiency and leaching of nutrients below the root zone. Soil erosion also can be aggravated under frequent, intense furrow irrigation.

Sprinkler irrigation has the potential to reduce the amounts of water required to keep onions at a high water potential by closely matching water applications to evapotranspiration. In addition, applications of nutrients through the sprinkler system would be substantially more efficient than with furrow irrigation. The water impact from sprinkler irrigation can compact the soil surface, tending to reduce water infiltration and soil aeration over time. Also, onion foliage is subjected to repeated wetting by sprinklers could develop diseases.

Subsurface drip irrigation not only has the potential of increasing water use efficiency and fertilizer application efficiency, but also avoids any water drop impact on the soil surface and wetting of onion tops. Drip and sprinkler irrigation could reduce or eliminate leaching of water below the root zone, and reduce or eliminate surface soil erosion associated with furrow irrigation. Fields under drip or sprinkler irrigation could also have uniform yield and grade throughout the length of the field. This trial evaluated furrow, sprinkler, and drip irrigation systems for onion production, water use, and nitrate leaching.

Procedures

Before planting, the soil profile was sampled down to 6 feet on March 29 and analyzed in 1 foot increments for ammonium-N and nitrate-N for all replicates. The soil analyses for the first foot showed a pH of 7.5, 8 CEC, 7 ppm nitrate-N, 7 ppm ammonium-N, 24 ppm phosphorus, 192 ppm potassium, 2,200 ppm calcium, 260 ppm magnesium, 111 ppm sodium, 1.7 ppm zinc, 6 ppm iron, 13 ppm manganese, 1 ppm copper, 10 ppm sulfate-S, and 0.4 ppm boron. The field was moldboard plowed and groundhogged twice in the fall of 1992, and worked into beds in the spring of 1993. Black polyethylene drip lines were buried 4 inches deep on April 24. Onions were planted on April 31 using an Amalco cone seeder mounted on a John Deere Flexi-Planter. Dacthal at 8 lbs ai/ac and diazinon at 3 lbs ai/ac were broadcast on May 3. The field was then irrigated with a solid set sprinkler system to assure uniform onion emergence. The soil conditioner polyacrylamide at 2 lbs/ac was applied to the irrigation water along with ammonium sulfate at 1.6 lb/ac to reduce surface crusting.

The experimental design was a split plot with the irrigation systems as the main plots and the four varieties were split plots within the main plots. Each of the three irrigation systems was replicated six times. The irrigation systems were arranged in a randomized complete block design and the varieties were randomized within each treatment. The varieties used were Great Scott (yellow bulbs, Scottseed), Magnum (yellow bulbs, Sunseeds), Blanco Duro (white bulbs, Sunseeds), and Tango (red bulbs, Sunseeds).

Furrow plots were four 44-inch beds wide (14.7 feet) by 80 feet long, and drip and sprinkler plots were six 88-inch beds wide (44 feet) by 80 feet long (Table 1). Onions were planted on two double rows (1 seed/4 inches) spaced 22 inches apart per bed in the furrow plots (Table 1). In order to take advantage of the better water distribution capability of sprinkler and drip systems, planting was done on nine single rows spaced 8 inches apart (1 seed/3 inches) on the central 64 inches of the beds in the drip and sprinkler plots (Table 1). This planting system could result in a more efficient use of area than the planting system used with furrow irrigation.

Table 1. Onion planting design specifications for three irrigation systems. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Irrigation system	Bed width	Number of onion rows/bed	Row spacing	In-row seeding rate	Total seeding rate
	inches		inches		seeds/ac
Furrow	44	4 (2 double)	22	1 seed/4 inches	142,560
Drip and sprinkler	88	9 single	8	1 seed/3 inches	213,840

Each furrow irrigation plot was served with gated pipe and tail ditch. Each drip irrigated bed had three drip lines spaced 24 inches apart. Each drip line was placed below an onion row so as to have one drip line service three onion rows. Drip tubing had 0.3 gal/hr/100 ft emitters spaced 12 inches apart. The water in the drip lines was adjusted to maintain a pressure of 10 psi. The sprinkler plots were serviced by two sprinkler lines spaced 44 feet apart with risers spaced 40 feet apart in the line and staggered 20 feet. Sprinkler heads were adjusted to a 180° angle of spray so that water did not go onto the furrow or drip irrigated onions. Water application rate for the sprinkler plots was 0.2 inch per hour at a pressure of 50 psi.

Soil water potential was monitored by two granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) 8 inches deep below an onion row (top of each GMS was 6 inches from the soil surface) in each plot. The drip and sprinkler plots had additional GMS 20 inches below the soil surface (top of GMS 18 inches below the soil surface). In the drip and sprinkler plots the GMS were placed below one of the four onion rows that were spaced 8 inches to the side of the drip lines. Onion evapotranspiration (Et_c) was calculated from weather data collected by the AgriMet weather station at the Malheur Experiment Station.

Irrigation treatments were started on May 21. Furrow plots were irrigated when the average soil water potential in the first foot of soil reached -25 kPa. Plots were irrigated long enough for the wetting front to reach laterally just beyond the row of onion plants. Because of the high water application efficiency of drip irrigation, it is feasible to keep the soil at a more constant water potential. Consequently, the drip plots had the previous days ET_c replaced five days a week. Sprinkler plots were irrigated when the accumulated Et_c reached 1 inch. Applying low amounts of water with sprinkler irrigation, such as when replacing the accumulated Et_c daily, sharply increases the evaporative losses. In addition, the first foot soil moisture sensors had been found previously not to respond when water applications with sprinkler irrigation were less than 1 inch on silt loam soil.

The field was sprayed with Karate at 0.02 lb ai/ac for thrips control along with 2 pints/ac of ZKP on July 8. On June 17 and July 15 the field was sprayed with 0.34 lb ai/ac Poast, 0.16 lb ai/ac of Buctril, and 0.12 lb ai/ac of Goal for weed control. Prowl at 0.5 lb ai/ac was broadcast on July 16. Uran at 25 lbs N/ac was applied through the drip and sprinkler systems on June 11, and on July 21, 26, and 28. Urea at 50 lbs N/ac was broadcast on June 11 and incorporated by rainfall on June 12 in the furrow plots. The furrow plots received an additional 25 lbs N/ac as water-run urea on July 20 and August 12. Due to low leaf tissue K_2O levels on July 2, KCl was water run in the furrow plots and applied through the drip and sprinkler systems at 50 lbs K_2O/ac on July 10, and at 25 lbs K_2O on August 3.

Tops from five Great Scott onions in each plot were taken for analysis of nitrogen content. Onions were lifted on September 20 and were topped and harvested on October 7. After harvest the soil was sampled in 1 foot increments down to 6 feet in each plot and analyzed for nitrate and ammonium. Onions were graded out of storage on December 15. Onion bulb tissue samples were taken at grading for analysis of dry weight and N content. Top dry weight yield was estimated based on a ratio of top/bulb dry weight of 0.16 calculated for similarly fertilized onions. Nitrogen contribution from the irrigation water was estimated to be 1.4 lb N/ac-inch of water infiltration. Available-N contributed by organic matter mineralization, less nitrogen leaching losses, was calculated by adding the nitrogen taken up by the crop to the nitrogen in the profile after harvest ("accounted N") and subtracting the available nitrogen in spring plus fertilizer added.

Results

The 1993 growing season was cooler than the six year average and the coolest recorded at the weather station with 22 percent fewer growing degree days (50-86 °F) from May through September. Consequently, onion plants were not adequately mature when lifted and onions were not adequately cured at harvest time. As a result, rot was anticipated in storage. In order to reduce the excessive Botrytis in storage, the onions were heated in a forced air dryer for 80 minutes at 100 °F before storage.

The pattern of changes in soil water potential during the season differed between irrigation systems (Figures 1-3). Soil water potential in the second foot of soil in the drip plots remained slightly wetter than in the first foot of soil and tracked the changes in the first foot of soil (Figure 2). The soil water potential in the second foot of soil in the sprinkler plots showed a small but constant decrease during the season and was not affected by the wetting pattern in the first foot of soil (Figure 3). The average soil water potential at 8-inch depth for the period between May 27 and August 9 was drier for the sprinkler irrigation system (-17 kPa under sprinklers, verses -12 kPa under drip and -10 kPa under furrow).

Total water applied to the drip plots was 19.6 ac-inches and to the sprinkler plots was 18.8 ac-inches. Onion evapotranspiration totaled 16.3 ac-inches. The amounts of water applied to the furrow plots are not representative of commercial agriculture due to the short runs (80 foot plots) and the impractability of adjusting the gates on the gated pipe to low enough flow rates. The amounts of water applied to the drip and sprinkler plots were close to Et_c and were substantially lower than the 4 ac-feet or more typically applied to furrow irrigated onions (Figure 4).

Over all varieties, the drip and sprinkler plots had significantly higher total yields than the furrow plots (Table 2). The higher seeding rate in the drip and sprinkler plots resulted in a large mass of green onion tops. Due to the late planting date and low heat units, these onions failed to mature properly in the field. Sprinkler irrigation resulted in the highest marketable yield over all varieties. The drip plots had the highest proportion of rotten onions and consequently had the lowest proportion of marketable onions (Table 3). Furrow irrigation resulted in the highest yield of colossal onions over all varieties, suggesting that perhaps the higher in-row seeding rate used in the drip and sprinkler beds resulted in excessive plant competition for full bulb enlargement especially since the 1993 season was shortened by late planting and low heat units.

Total yield of all varieties was highest with drip or sprinkler irrigation. However, Great Scott marketable yields did not differ significantly between irrigation systems. Tango marketable yields were highest with sprinkler or drip irrigation. Magnum and Blanco Duro marketable yield was highest with sprinkler irrigation, consistent with their known adaptation to sprinkler irrigation.

Higher amounts of available-N were present at harvest than at planting in the soil profile and in the top 2 feet for all three irrigation systems (Figure 5, Tables 3 and 4). Nitrogen recovery was significantly higher for the drip and sprinkler plots than for the furrow plots suggesting that furrow irrigation resulted in greater N leaching losses (estimated to be about 41 lbs N/ac). The high amount of nitrogen estimated to have been released from organic matter mineralization, reemphasizes the importance of taking into account natural sources of available-N when making fertilizer recommendations.

Conclusions

Planting onions on nine rows in 88-inch beds under drip and sprinkler irrigation resulted in a significant increase in yield over the row and bed spacing used under furrow irrigation. The soil remained as wet with drip and sprinkler irrigation as with furrow irrigation, using vastly less water. The higher proportion of colossal onions under furrow irrigation suggests that a reduction of the in-row seeding rate in the drip and sprinkler plots from 1 seed/3 inches to 1 seed/4 inches could improve the proportion of colossal onions. Drip and sprinkler irrigation resulted in a high proportion of rotten onions after storage, which may have also been related to high plant population but may have also been related to onion curing conditions particular to 1993. Curing of onions after lifting in 1993 was hampered by the onions not being fully mature at lifting time. In addition drip and sprinkler irrigation resulted in remarkably vigorous and dense top growth that covered the bulbs after lifting and inhibited curing. Marketable yields for drip and sprinkler irrigated onions would be substantially higher in a growing season with weather closer to the multi-year average.

Table 1. Influence of three irrigation systems on yield of four onion cultivars (comparing sprinkler and drip plots with 9 single rows on 88-inch beds and furrow plots with two double rows on 44-inch beds). Onion grade was determined after 10 weeks of storage. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

		Yield by market grade							
Irrigation system	Variety	Rot	#2	Small	Medium	Jumbo	Colossal	Marketable	Total
		cwt/ac							
Sprinkler	Great Scott	181	48	4	67	496	0	563	796
	Magnum	142	39	6	60	563	0	622	809
	Blanco Duro	250	17	5	62	295	0	357	628
	Tango	74	29	9	86	319	0	405	517
	Average	162	33	6	69	418	0	487	688
Subsurface Drip	Great Scott	282	60	3	51	426	0	477	822
	Magnum	248	52	3	48	426	0	474	776
	Blanco Duro	386	11	4	36	106	0	143	544
	Tango	67	31	14	94	320	0	414	526
	Average	246	39	6	57	320	0	377	667
Furrow	Great Scott	47	109	0	18	464	47	529	684
	Magnum	44	64	0	10	373	58	441	549
	Blanco Duro	213	20	0	10	149	4	162	394
	Tango	15	40	3	33	224	3	260	319
	Average	80	58	1	18	303	28	348	487
LSD(0.05) Treatment		100	20	4	22	71	12	89	87
LSD(0.05) Variety		54	11	2	10	51	8	55	38
LSD(0.05) Treatmnt X Var.		ns	20	4	ns	88	14	96	66

Table 2. Influence of three irrigation systems on market grade of four onion cultivars (comparing sprinkler and drip plots with 9 single rows on 88-inch beds and furrow plots with two double rows on 44-inch beds). Onion grade was determined after 10 weeks of storage. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment	Variety	Rot	Market grade distribution					
			#2	Small	Medium	Jumbo	Colossal	Marketable
			%					
Sprinkler	Great Scott	22.5	6.0	0.5	8.5	62.5	0.0	71.0
	Magnum	17.7	4.8	0.8	7.3	69.4	0.0	76.7
	Blanco Duro	40.1	2.7	0.8	10.0	46.5	0.0	56.5
	Tango	16.6	6.3	1.9	17.7	57.5	0.0	75.3
	Average	24.2	5.0	1.0	10.9	59.0	0.0	69.9
Drip	Great Scott	32.7	7.3	0.4	6.7	53.0	0.0	59.6
	Magnum	31.2	6.7	0.4	6.4	55.4	0.0	61.8
	Blanco Duro	71.0	1.9	0.8	7.2	19.1	0.0	26.3
	Tango	12.5	5.9	2.8	18.2	60.7	0.0	78.8
	Average	36.9	5.5	1.1	9.6	47.1	0.0	56.6
Furrow	Great Scott	6.7	15.6	0.0	2.7	68.1	6.8	77.6
	Magnum	7.8	11.7	0.0	2.0	67.9	10.5	80.4
	Blanco Duro	52.8	5.0	0.0	2.4	38.7	1.0	42.2
	Tango	5.0	12.5	1.0	10.9	69.5	1.1	81.5
	Average	18.1	11.2	0.3	4.5	61.1	4.9	70.4
LSD(0.05) Treatment		12.1	2.8	1.0	4.8	12.6	2.0	13.4
LSD(0.05) Variety		8.2	1.7	0.5	2.6	8.1	1.1	8.3
LSD(0.05) Treatment X Var.		14.2	3.0	ns	ns	ns	2.0	ns

Table 3. Influence of three irrigation systems on available nitrogen accounting in onions and in the soil profile (0-6 ft) between the pre-plant sampling and the post-harvest. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Irrigation system	Available N supply				Fall nitrogen accounting		
	Pre-plant soil available N (0-6')	Fertilizer N	N in irrigation water	Estimated N from organic matter mineralization less leaching*	Fall soil available N (0-6')	Plant N recovery	Total accounted N
	lb/ac						
Sprinkler	172	100	25	167	309	155	464
Drip	172	100	44	141	299	158	457
Furrow	172	100	22	126	307	113	420
LSD(0.05)				ns	ns	20	ns

* Based on the difference between N supplies and fall N accounting.

Table 4. Influence of three irrigation systems on available nitrogen accounting in onions and in the soil surface (0-2 ft) between the pre-plant and post harvest. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Irrigation system	Spring available N				Fall nitrogen accounting		
	Pre-plant soil available N (0-2')	Fertilizer N	N in irrigation water	Estimated N from organic matter mineralization less leaching losses*	Fall soil available N (0-2')	Plant N recovery	Accounted N
	lb/ac						
Sprinkler	64	100	25	111	145	155	300
Drip	64	100	44	91	141	158	299
Furrow	64	100	22	58	131	113	244
LSD(0.05)				ns	ns	20	41

* Based on the difference between N supplies and fall N accounting.

Figure 1. Soil water potential over time in the first foot of soil for furrow irrigated onions irrigated when the surface soil water potential reached -25 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

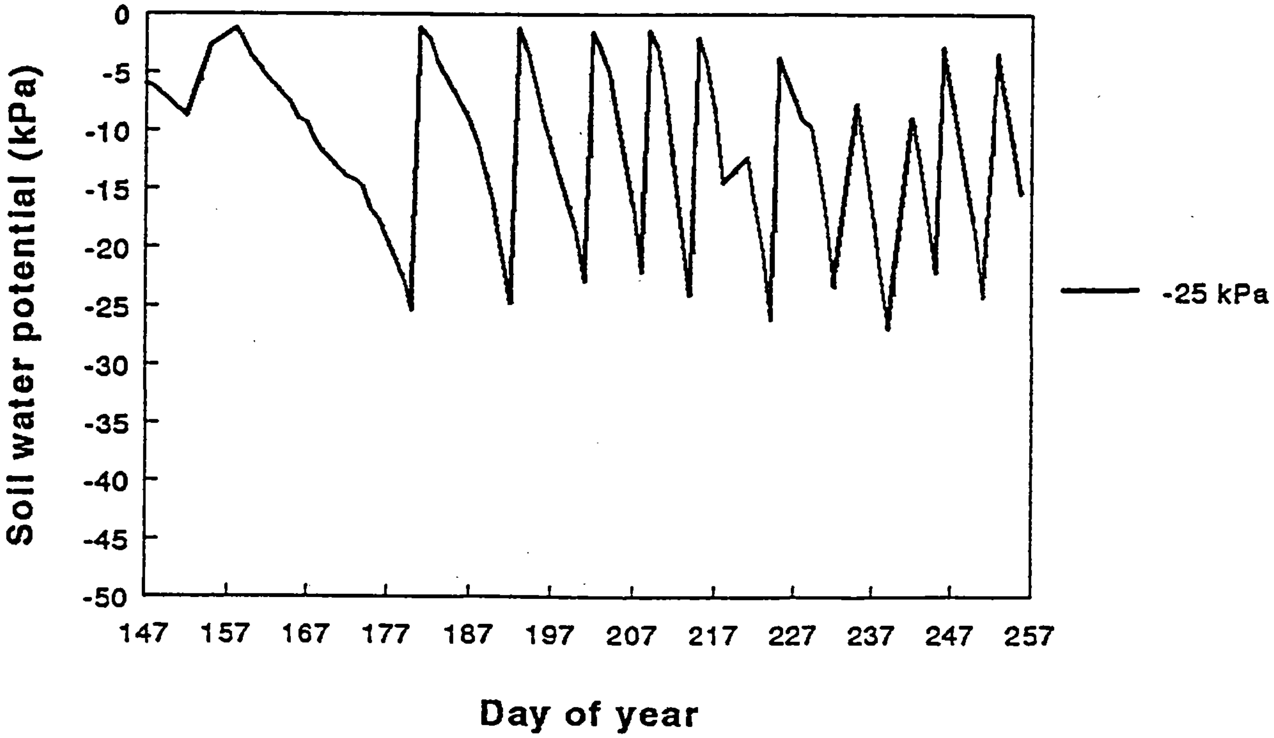


Figure 2. Soil water potential over time for drip irrigated onions with full evapotranspiration replacement. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

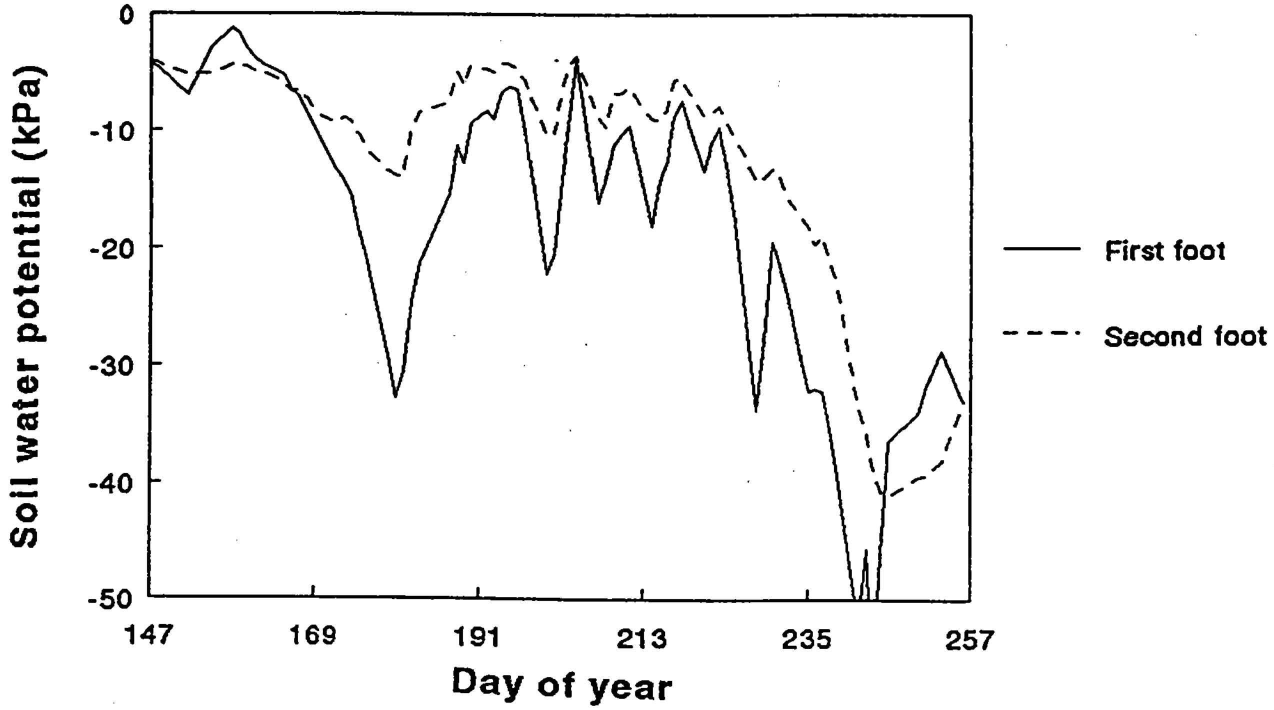


Figure 3. Soil water potential over time for sprinkler irrigated onions with full evapotranspiration replacement. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

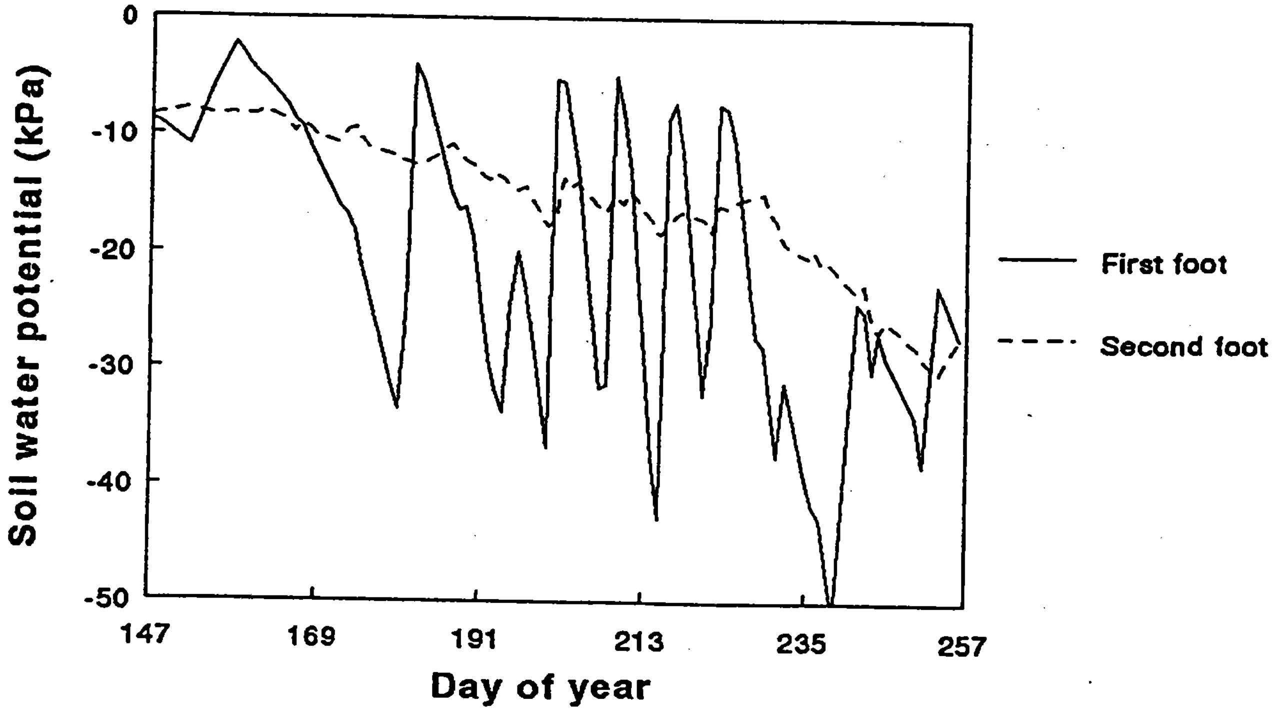


Figure 4. Cumulative onion evapotranspiration and water applied for subsurface drip and sprinkler irrigated onions. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

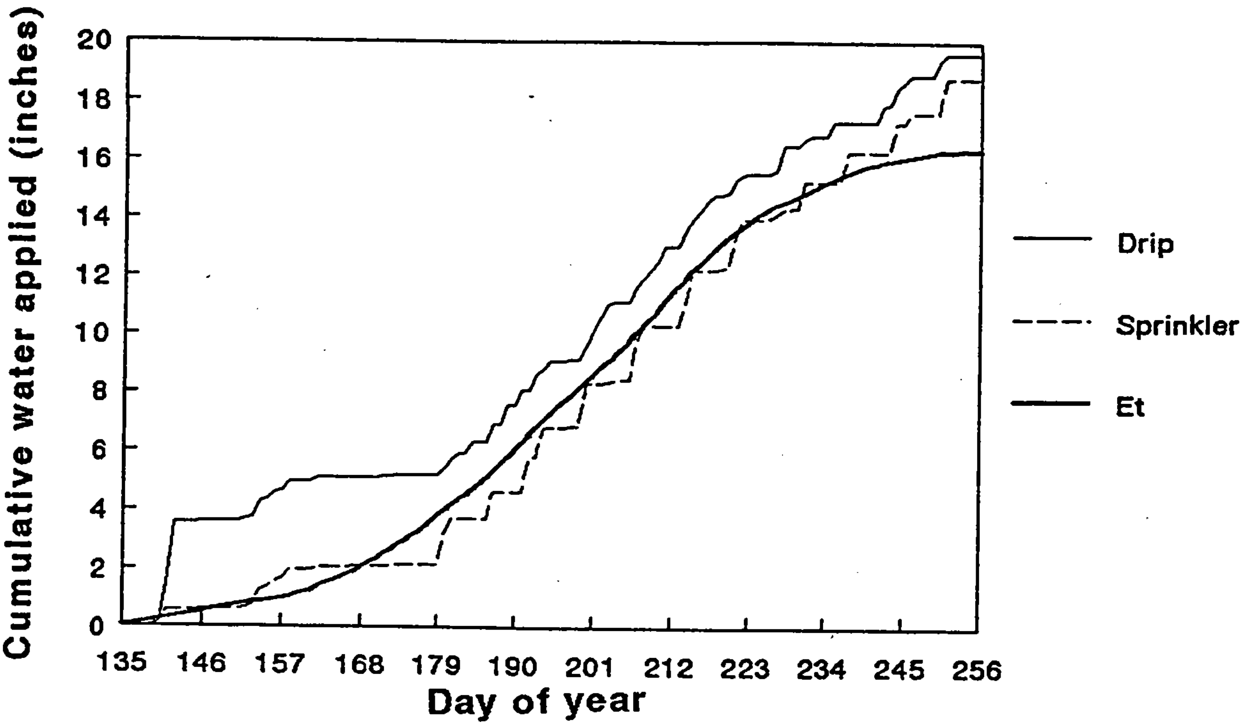
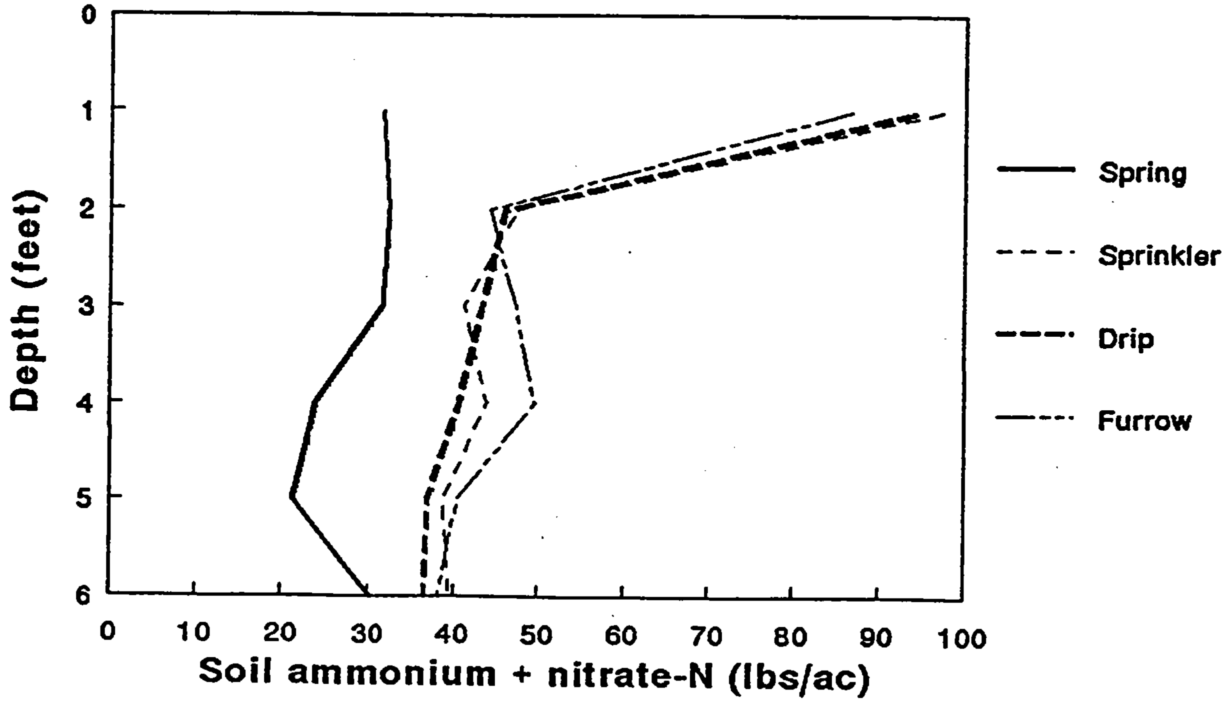


Figure 5. Influence of three irrigation systems on post harvest available soil nitrogen compared to pre-plant (spring) levels. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.



SOIL WATER POTENTIAL CRITERIA
FOR ONION IRRIGATION

Erik Feibert, Clint Shock and Monty Saunders
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Introduction

Onion production in the Treasure Valley of Oregon and Idaho requires large amounts of surface irrigation; 4 acre-feet of water per acre or more are often applied. A literature search of crop water use requirements suggests that onion water requirements may be in the range of 2 to 2.5 acre feet per acre without consideration of irrigation system inefficiencies.

Currently most irrigation scheduling methods use a reference percent of available soil water (75 percent for onions) to which the soil is depleted before an irrigation is advised (Heermann et al. 1990). These reference values have not been adequately correlated with optimum crop yields, crop quality, or water use efficiency. The use of these values to schedule irrigations could lead to the crop being over- or under-irrigated. The determination of the amount of available soil water depleted may be based solely on evapotranspiration loss converted for the crop from a local evapotranspiration value through a correction factor for the specific crop and soil (U.S. Bureau of Recl., 1991). This correction factor varies with location and cultural methods (Ritchie and Johnson, 1990), and thus the calculation of the available soil moisture is only a crude estimate.

The use of tensiometers and granular matrix sensors (GMS) that measure soil water potential to schedule irrigations allows for a more accurate estimation of the soil water status. However, few studies have sought to determine the ideal soil water potential for onions (Brewster, 1990). A study in Norway found that maintenance of the soil water potential wetter than -40 kPa (-0.4 bars) resulted in the highest onion yields (Dragland, 1974). The optimum soil water potential for onions in the 1992 trial at the Malheur Experiment Station was -25 kPa (Feibert et al., 1993). The determination of the ideal soil water potential to be used as a guide for scheduling onion irrigations could improve the water use efficiency of this crop. Less nitrate might be leached below the root zone. The objective of this trial is to determine the soil water potential for Treasure Valley onions that will result in optimum yield, quality, and storability.

Procedures

Before planting, the soil profile was sampled down to 6 feet on March 29 and analyzed in 1 foot increments for ammonium and nitrate for all replicates. The soil analyses for the first foot showed a pH of 7.5, 8 CEC, 7 ppm nitrate-N, 7 ppm ammonium-N, 24 ppm phosphorus, 192 ppm potassium, 2200 ppm calcium, 260 ppm magnesium, 111 ppm sodium, 1.7 ppm zinc, 6 ppm iron, 13 ppm manganese, 1 ppm copper, 10 ppm sulfate-S, and 0.4 ppm boron. The field was moldboard plowed and groundhogged twice in the fall of 1992 and worked into 44-inch beds in the spring of 1993. Onions were planted on April 31 on two double rows (1 seed/4 inches) spaced 22 inches apart per bed using an Amalco cone seeder mounted on a John Deere Flexi-Planter. Dacthal at 8 lbs ai/ac and diazinon at 3 lbs ai/ac were broadcast on May 3. The field was then irrigated with a solid set sprinkler system to assure uniform onion emergence. The soil conditioner polyacrylamide at 2 lbs/ac was applied to the irrigation water along with ammonium sulfate at 1.6 lb/ac.

Furrow irrigation treatments were started on May 21. The five irrigation treatments consisted of five soil water potential thresholds (-12.5, -25, -37.5, -50, -75, and -100 kPa). When the average soil water potential for a treatment reached that treatment's criterion, the plots were irrigated. Plots were irrigated long enough for the wetting front to reach laterally just beyond the row of onion plants. Soil water potential was monitored by two granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) centered 8 inches deep below the onion row (top of GMS was 6 inches from the soil surface) in each plot.

The GMS readings, taken with a hand-held digital meter, which was previously calibrated (Eldredge et al., 1993), showed a good correlation to the tensiometer readings. The equation for the regression line is $Y= -2.12-1.015*X$, where Y equals the tensiometers readings and X equals the GMS readings ($r^2 = 0.69$, $p< 0.0001$).

Plots were four beds wide (14.7 feet) by 80 feet long. Each of the six irrigation treatments was replicated six times. The experimental design was a split plot with the irrigation treatments as the main plots, and the four varieties were split plots within the main plots. The treatments were arranged in a randomized complete block design and the varieties were randomized within each treatment. The varieties used were Great Scott (yellow bulbs, Scottseed), Magnum (yellow bulbs, Sunseeds), Blanco Duro (white bulbs, Sunseeds) and Tango (red bulbs, Sunseeds). Each plot in each replicate was served with gated pipe and tail ditch so that it could be irrigated individually.

The field was sprayed with Karate at 0.02 lb ai/ac for thrips control along with 2 pints/ac of ZKP on July 8. On June 17 and July 15 the field was sprayed with 0.34 lb ai/ac Poast, 0.16 lb ai/ac of Buctril and 0.12 lb ai/ac of Goal for weed control. Prowl at 0.5 lb ai/ac was broadcast on July 16. Urea at 50 lbs N/ac was broadcast on June 11 and incorporated by rainfall on June 12. The field received an additional 25 lbs N/ac as water-run urea on July 20 and August 12. Due to low leaf tissue K_2O levels on July 2, KCl was water-run at 50 lbs K_2O/ac on July 10 and at 25 lbs K_2O on August 3.

Plant heights were taken for Great Scott onions in all plots on August 30. Tops from five Great Scott onions in each -25 kPa plot were taken for analysis of nitrogen content. Onions were lifted on September 20 and were topped and harvested on October 7. Onions were graded out of storage on December 15. Onion bulb tissue samples were taken at grading for analysis of dry weight and N content. Top dry weight yield was estimated based on a ratio of top/bulb dry weight of 0.16 calculated from previous data for similarly fertilized onions. The soil was sampled in 1 foot increments down to 6 feet in each plot after harvest and analyzed for nitrate and ammonium. Nitrogen contribution from the irrigation water was estimated to be 1.4 lb N/ac-inch of water infiltration. Available-N contributed by organic matter mineralization less leaching losses was estimated by available-N accounting. The change in total available nitrogen is calculated by adding the nitrogen taken up by the crop to the nitrogen in the profile after harvest ("accounted N") and subtracting the available-N in spring (ammonium plus nitrate) plus fertilizer added.

Results

The 1993 growing season was cooler than the six year average and the coolest in recorded history with 22 percent fewer growing degree days (50-86 °F) from May through September. Onion evapotranspiration was only 16.3 ac-inch for this trial in 1993. Consequently, onion plants were not adequately mature when lifted and onions were not adequately cured at harvest time. As a result, in order to reduce the excessive rot anticipated in storage, the onions were heated in a forced air dryer for 80 minutes at 100 °F before storage.

The measured soil water potential in the first foot of soil was consistent with the experimental design (Figures 1-6). The amount of water required by each treatment increased with the increasing wetness of the treatments (Table 1). Data for the amounts of water applied on a per area basis to each treatment are far higher than typical for growers' fields because of the short irrigation runs (80 ft plots). Consequently, the number of hours of irrigation was reported to compare water use.

Great Scott plant heights increased with the increasing wettness of the treatments up to -25 kPa (Table 1). Onion yield and grade were responsive to the soil water potential treatments (Tables 1 and 2). Over all varieties, there was a trend for an increase in total, colossal, and rotten onion yield with the wetter treatments (Table 1). The -12.5 kPa treatment was among the highest in total yield, yield of colossal onions, and yield of rotten onions over all varieties. The -25 kPa treatment was among the highest in marketable yield over all varieties. Over all varieties grown in 1993, total yield peaked at -25 kPa and marketable yield peaked at -50 kPa.

The varieties differed in yield, grade and grade distribution (Tables 1 and 2). Magnum, Blanco Duro, and Tango are varieties adapted to sprinkler irrigation and yielded less under furrow irrigation than Great Scott. For Great Scott and Magnum the -12.5 kPa treatment was among the highest in total yield, and the -25 kPa and -37.5 kPa treatments were among the highest in marketable yield out of storage. For Blanco Duro the treatments -37.5 kPa or wetter had the highest total yield, while -50 or -37.5 kPa provided the largest marketable yield out of storage. Tango total yield and marketable yield out of storage at -12.5 and -25 kPa treatments were among the highest, reflecting significantly lower rot compared to the other varieties (Tables 1 and 2). Blanco Duro had the highest proportion of rotten onions and Tango had the lowest.

The amount of available-N (nitrate + ammonium nitrogen) in the soil profile and in the top 2 feet was greater at harvest than in the spring for all irrigation treatments (Figure 7, Tables 3 and 4). Plant nitrogen recovery increased with increasing soil water potential (wetter soil). The amounts of available N estimated to have been contributed from organic matter mineralization less leaching losses ranged from 33 to 67 lbs N/ac in the top 2 feet and from 80 to 159 lbs N/ac in the profile (Tables 3 and 4). The higher amounts of available-N in fall compared to spring, and the significant amounts of available-N estimated to have been contributed from organic matter mineralization suggest that leaching was minimal and reemphasize the importance of taking into account natural sources of available soil nitrogen when making fertilization recommendations.

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Table 1. Response of onion plant height, yield and grade of four cultivars to six soil water potential treatments. Onion grade was determined after 10 weeks of storage. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment	Number of irrigations	Total hours of irrigation	Variety	Plant height	Yield by market grade							
Irrigation criteria					Rot	#2	Small	Medium	Jumbo	Colossal	Marketable	Total
kPa				inches	cwt/ac							
-12.5	17	223	Great Scott	27.1	173	66	0	10	389	64	463	702
			Magnum		126	74	0	5	307	67	379	579
			Blanco Duro		252	16	1	7	108	4	119	388
			Tango		19	35	4	23	245	13	280	338
			Average		143	48	1	11	262	37	310	502
-25	11	148	Great Scott	26.4	47	109	0	18	465	47	529	686
			Magnum		44	64	0	10	373	58	441	549
			Blanco Duro		213	20	0	10	149	4	162	394
			Tango		15	40	3	33	224	3	260	319
			Average		80	58	1	18	303	28	348	487
-37.5	8	102	Great Scott	24.4	41	61	2	16	440	29	486	589
			Magnum		20	35	1	17	364	20	401	457
			Blanco Duro		116	20	2	53	198	1	252	391
			Tango		8	26	8	37	184	1	222	264
			Average		46	36	3	31	297	13	340	425
-50	5	60	Great Scott	22.4	25	29	4	34	427	4	464	522
			Magnum		9	18	1	28	313	4	345	373
			Blanco Duro		31	11	5	50	192	1	243	290
			Tango		4	17	5	44	172	2	218	244
			Average		17	19	4	39	276	3	318	357
-75	3	43	Great Scott	19.5	12	10	6	62	299	0	361	389
			Magnum		13	4	6	50	251	0	301	327
			Blanco Duro		22	6	7	51	154	0	205	238
			Tango		3	5	8	63	114	1	178	192
			Average		13	6	7	57	205	0	261	287
-100	2	22	Great Scott	16.5	12	5	13	94	128	0	223	253
			Magnum		5	4	20	81	91	0	172	198
			Blanco Duro		10	2	17	68	44	0	112	142
			Tango		2	0	22	67	35	0	102	126
			Average		7	3	18	78	75	0	152	180
LSD(0.05) Trt.				1.6	30	9	4	14	34	12	41	32
LSD(0.05) Var.					18	7	2	10	21	5	25	23
LSD(0.05) Trt.X					43	17	ns	24	52	18	61	56

Table 2. Market grade distribution response of four onion cultivars to six soil water potential treatments. Onion grade was determined after 10 weeks of storage. Malheur Experiment Station, Oregon State University, Ontario, Oregon 1993.

Treatment		Market grade distribution						
Irrigation criteria	Variety	rot	#2	small	medium	jumbo	colossal	marketable
		%						
-25 kPa	Great Scott	6.7	15.6	0.0	2.7	68.1	6.8	77.6
	Magnum	7.9	11.8	0.0	2.0	67.9	10.5	80.4
	Blanco Duro	52.8	5.0	1.5	2.4	38.7	1.0	42.2
	Tango	5.0	12.6	1.0	10.9	69.5	1.1	81.5
	Average	18.1	11.3	0.6	4.5	61.1	4.9	70.4
-37.5 kPa	Great Scott	6.7	10.1	0.2	3.0	74.9	5.1	82.9
	Magnum	4.4	7.8	0.3	3.7	79.2	4.6	87.5
	Blanco Duro	29.4	5.5	0.8	10.9	53.1	0.4	64.3
	Tango	3.1	9.9	2.9	14.2	69.5	0.3	84.1
	Average	10.9	8.3	1.1	8.0	69.2	2.6	79.7
-50 kPa	Great Scott	4.8	5.6	0.7	6.5	81.6	0.7	88.9
	Magnum	2.5	4.6	0.5	8.3	82.8	1.2	92.4
	Blanco Duro	10.3	3.8	1.8	17.5	65.9	0.7	84.2
	Tango	1.4	6.9	2.1	18.4	70.4	0.8	89.6
	Average	4.8	5.2	1.3	12.7	75.2	0.9	88.8
-75 kPa	Great Scott	3.2	2.5	1.8	16.7	75.8	0.0	92.5
	Magnum	3.8	1.9	1.9	15.6	76.7	0.0	92.3
	Blanco Duro	9.2	1.6	3.0	22.4	63.8	0.0	86.2
	Tango	1.2	2.3	4.2	33.9	57.9	0.4	92.2
	Average	4.4	2.1	2.7	22.2	68.6	0.1	90.8
-100 kPa	Great Scott	4.5	1.9	5.6	37.8	50.2	0.0	87.9
	Magnum	2.5	0.8	10.3	41.5	44.7	0.0	86.3
	Blanco Duro	6.8	2.6	11.1	49.1	30.4	0.0	79.4
	Tango	1.1	0.0	18.2	53.2	27.4	0.0	80.7
	Average	3.7	1.3	11.3	45.4	38.2	0.0	83.6
LSD(0.05) Treatment		6.3	1.5	2.5	4.8	7.7	2.2	7.5
LSD(0.05) Variety		3.9	1.3	1.2	2.4	3.6	1.2	3.9
LSD(0.05) Trt. X Var.		9.5	3.2	2.9	5.9	8.8	3.0	9.6

Table 3. Influence of soil water potential on available nitrogen accounting in onions and in the soil profile (0-6 feet) between spring pre-plant and post-harvest. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment	Available N supply 0-6 feet				Fall nitrogen accounting		
Irrigation criteria	Pre-plant soil available N (0-6')	Fertilizer N	N in irrigation water	N from organic matter mineralization less leaching losses*	Fall soil available N (0-6')	Plant N recovery	Total accounted N
kPa	lb/ac						
-12.5	172	100	22	110	285	119	404
-25	172	100	22	126	307	113	420
-37.5	172	100	22	80	276	98	374
-50	172	100	22	125	333	86	419
-75	172	75	16	130	327	66	393
-100	172	75	8	159	374	40	414
LSD(0.05)					65	10	ns

* Based on the difference between N supplies and fall N accounting.

Table 4. Influence of soil water potential on available nitrogen accounting in onions and in the top 2 feet of soil. Malheur Experiment Station, Oregon state University, Ontario, Oregon, 1993.

Treatment	Available N supply				Fall nitrogen accounting		
Irrigation criteria	Pre-plant soil available N (0-2')	Fertilizer N	N in irrigation water	N from organic matter mineralization less leaching losses*	Fall soil available N (0-2')	Plant N recovery	Total accounted N
kPa	lb/ac						
-12.5	64	100	22	67	134	119	253
-25	64	100	22	58	131	113	244
-37.5	64	100	22	33	121	98	219
-50	64	100	22	60	160	86	246
-75	64	75	16	37	149	66	215
-100	64	75	8	36	168	40	208
LSD(0.05)				ns	ns	10	ns

* Based on the difference between N supplies and fall N accounting.

Figure 1. Soil water potential over time in the first foot of soil for onions irrigated at -12.5 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

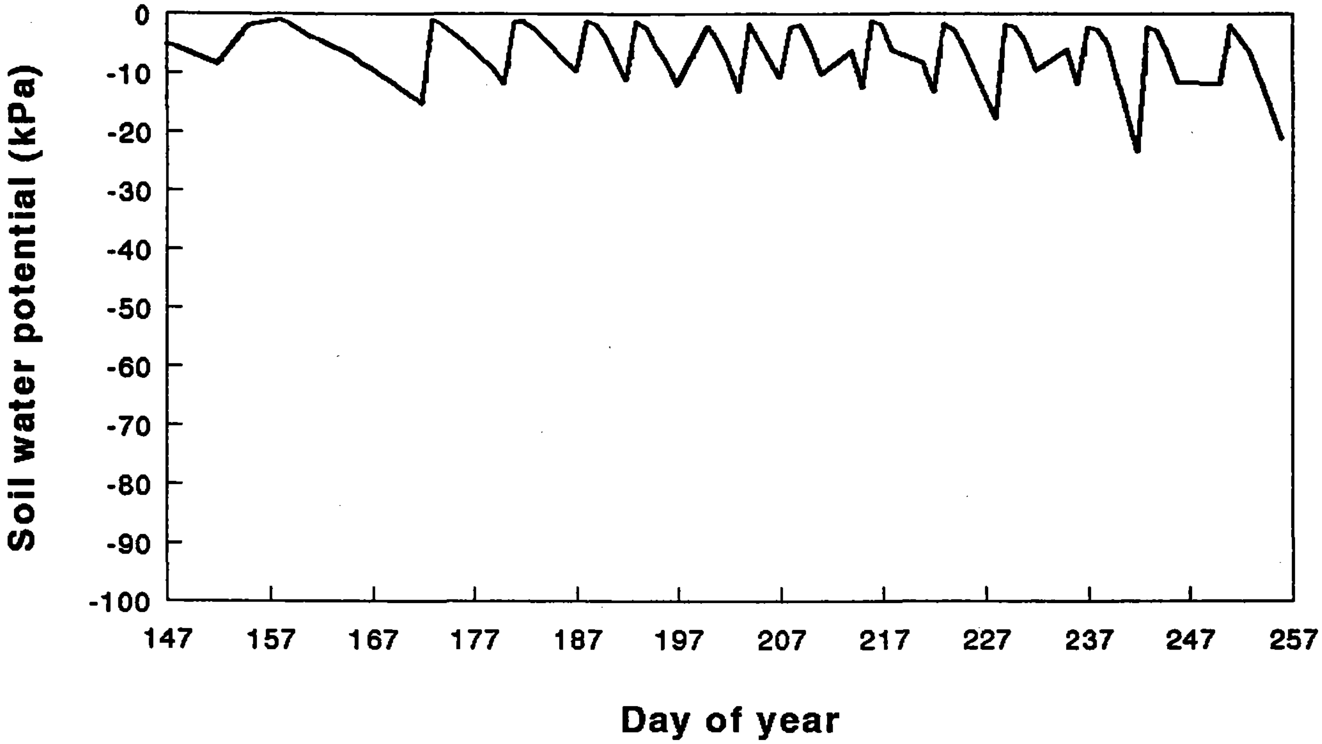


Figure 2. Soil water potential over time in the first foot for onions irrigated at -25 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

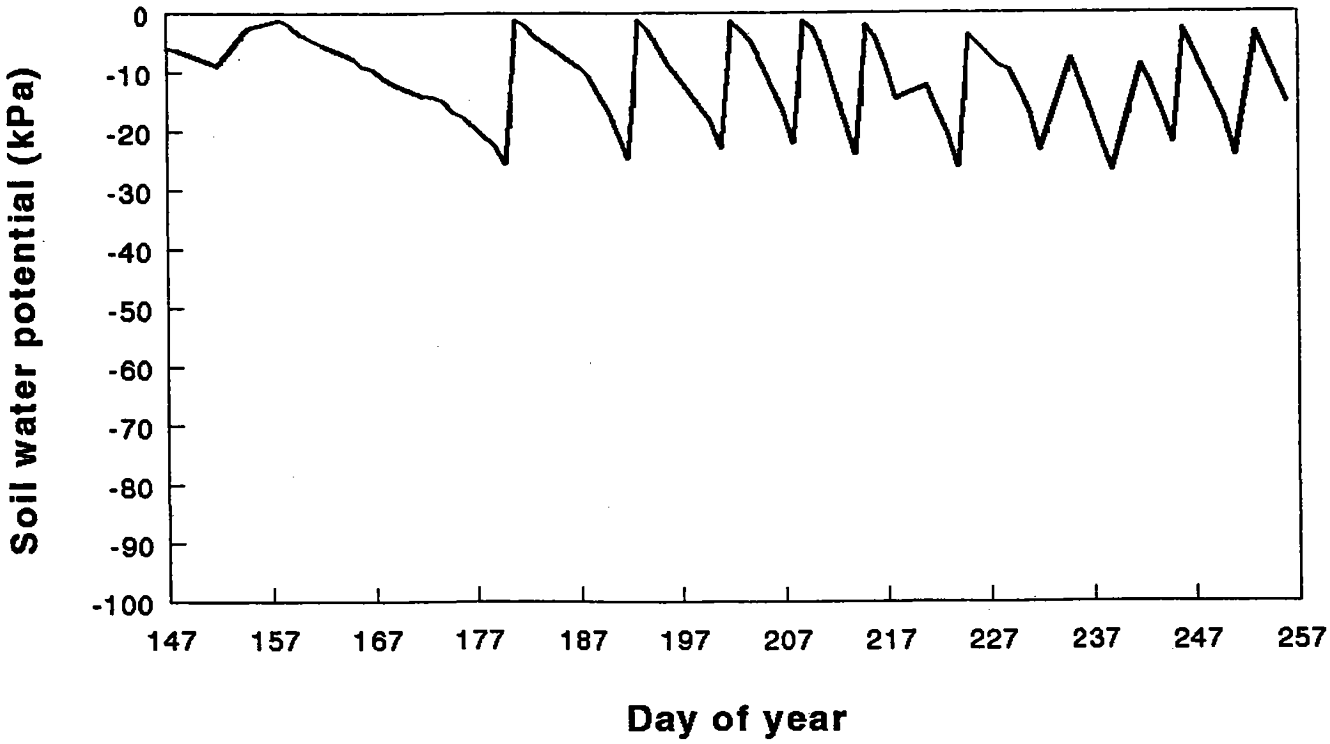


Figure 3. Soil water potential over time in the first foot for onions irrigated at -37.5 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

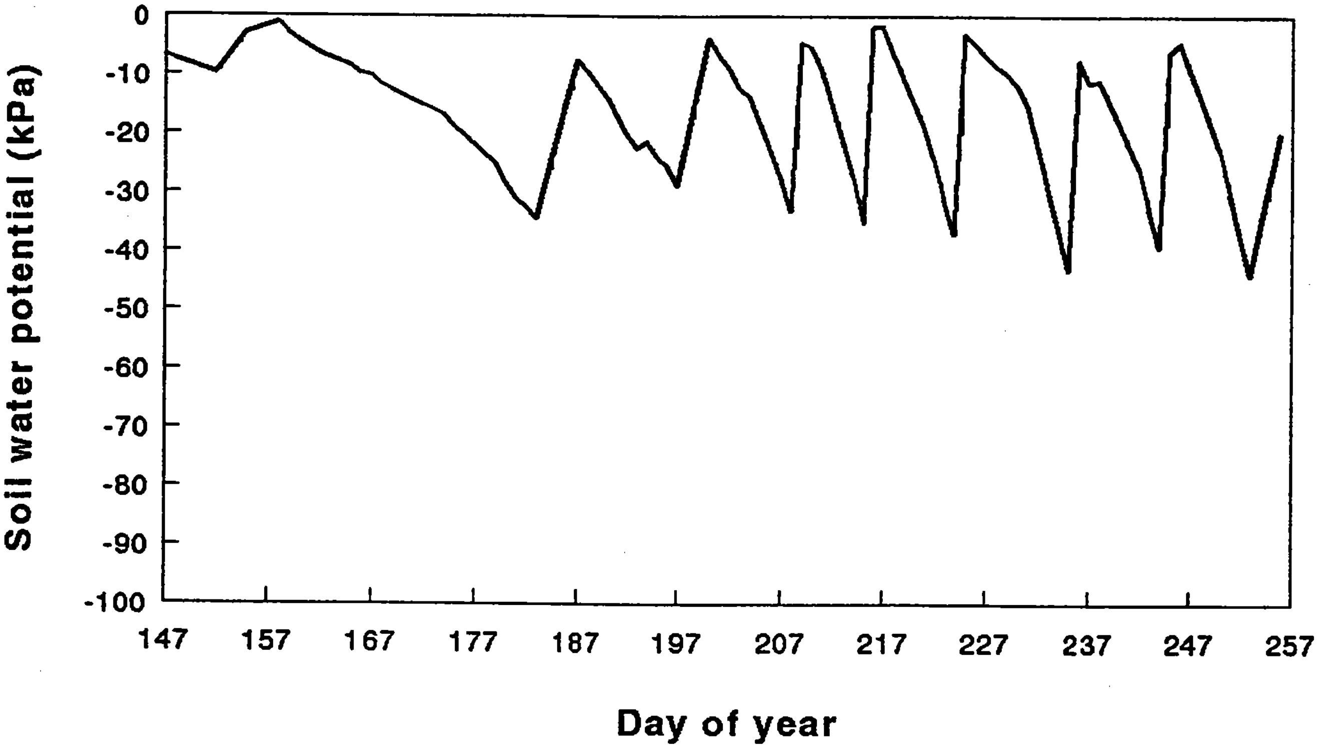


Figure 4. Soil water potential over time in the first foot for onions irrigated at -50 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

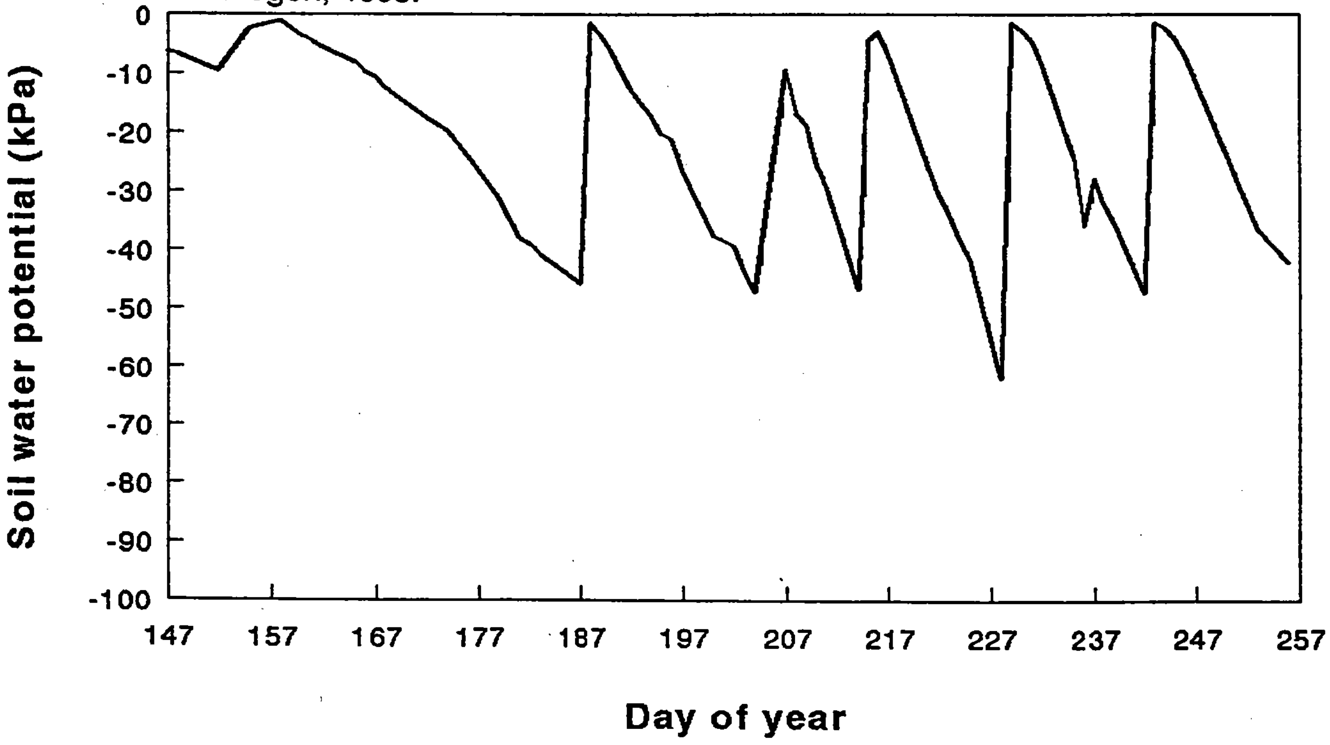


Figure 5. Soil water potential over time in the first foot for onions irrigated at -75 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

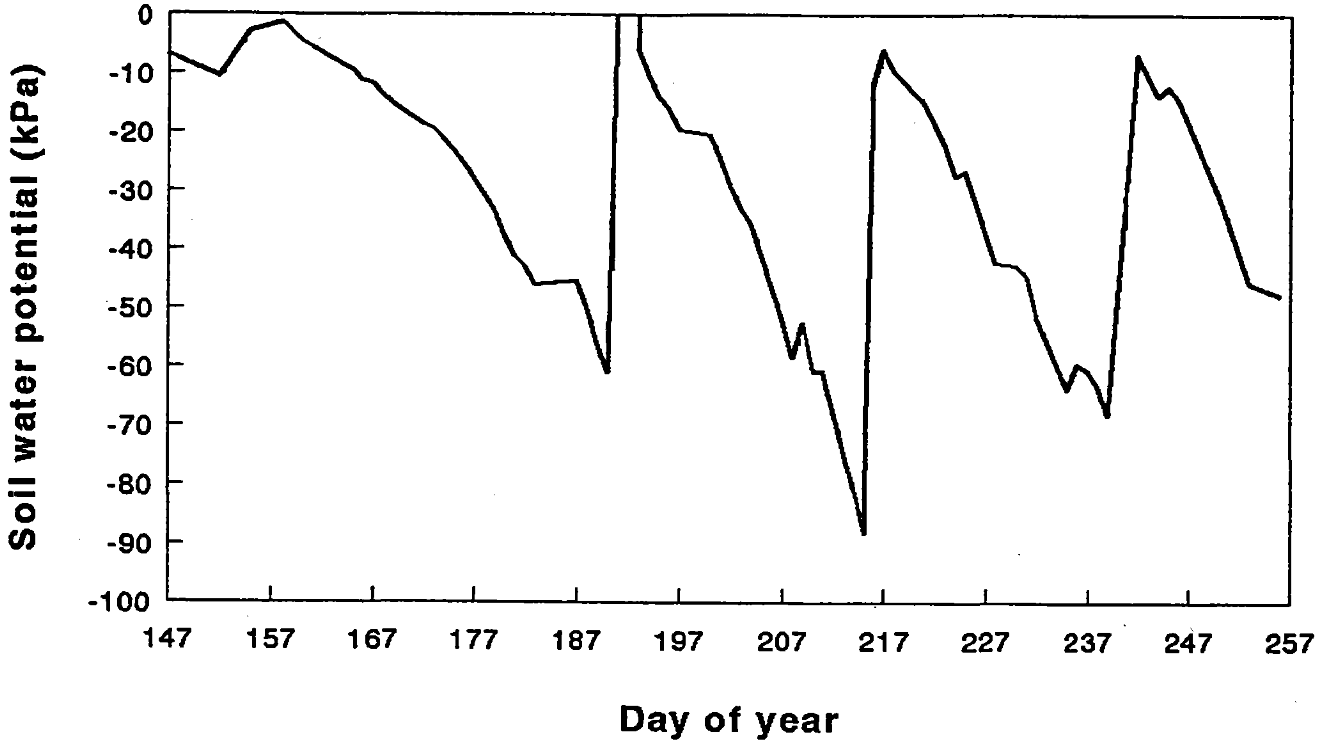


Figure 6. Soil water potential over time in the first foot for onions irrigated at -100 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

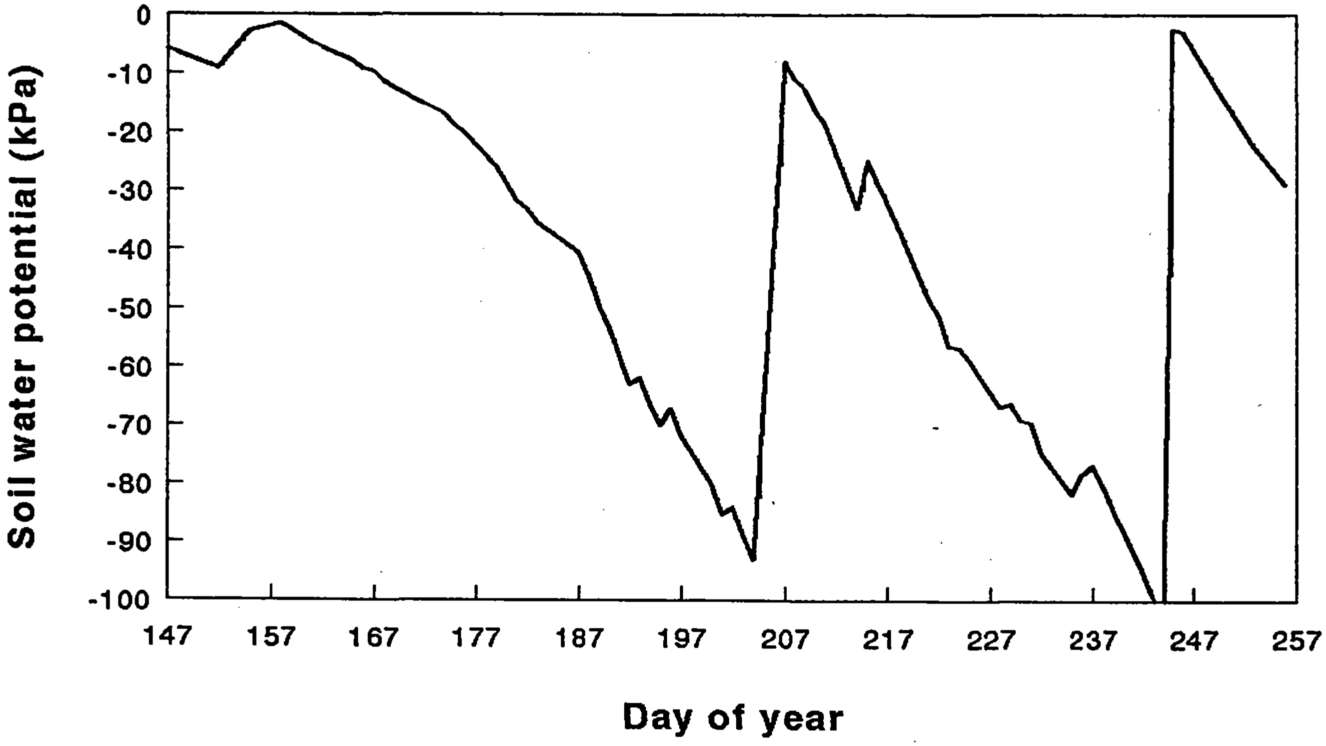
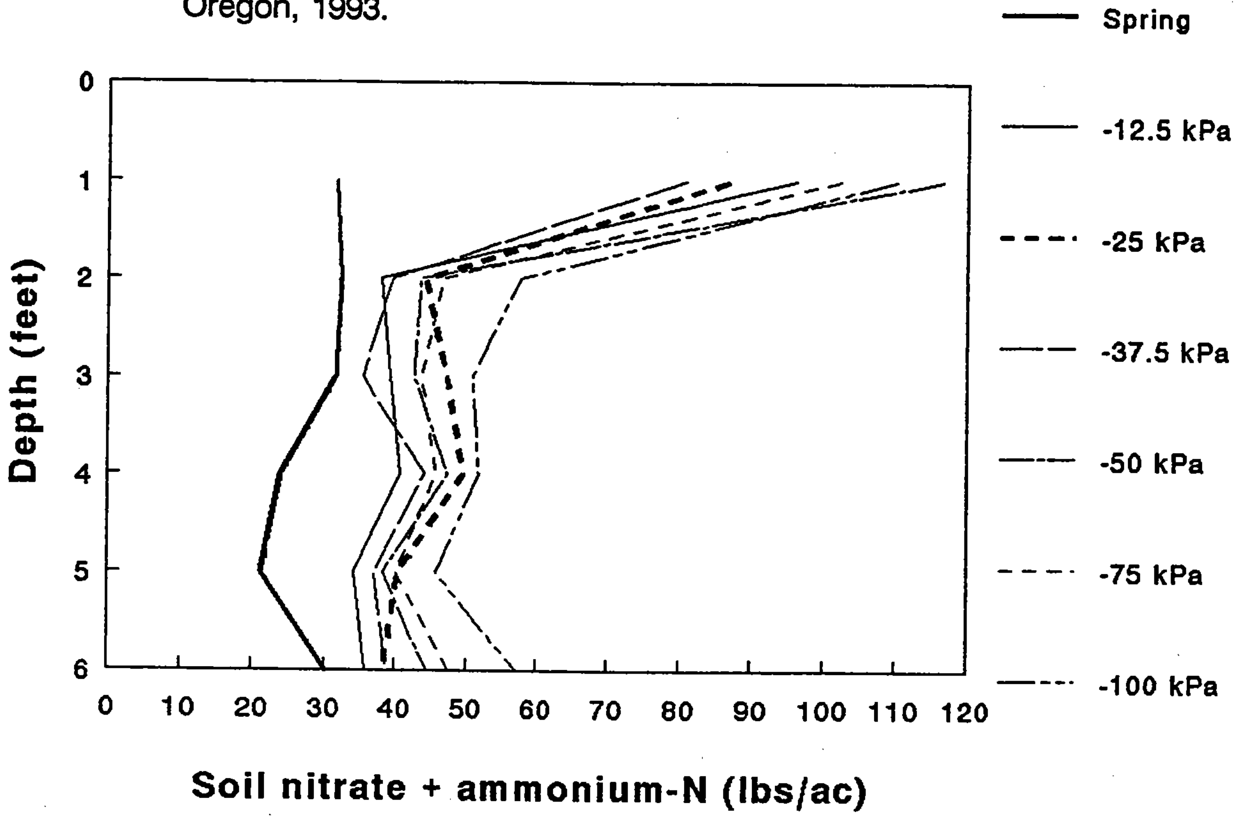


Figure 7. Influence of six irrigation treatments on available soil nitrogen in the fall (post-harvest) compared to the spring (pre-plant) under furrow irrigated onions. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.



STRATEGIES FOR CONTROLLING ONION THRIPS IN SWEET SPANISH ONIONS

Lynn Jensen
Malheur County Extension Office
Oregon State University
Ontario, Oregon

Many of the products used in this study are not presently registered for use on onions. If in doubt, read the label or consult a company representative or county agent.

Objectives

The purpose of this project was to compare the efficacy of new insecticides on onion thrips control and to determine if there was a rotation schedule for using different classes of insecticides that would result in better control through the growing season. There is a continuing need to screen new insecticides to determine if they are effective in controlling onion thrips. Because of the number of generations per year, thrips rapidly build up resistance to insecticides. Rotating between different classes of insecticides is one method of reducing build-up of resistance. Since the organo-phosphate class of insecticides is not fully effective on onion thrips, it is not known what type of rotation would be best suited for thrips control.

Materials and Methods

The trial was conducted on a 1 acre field of Pima onions, grown on the Paul Skeen farm south of Nyssa. The plots were four double rows (two beds) wide by 30 feet in length, and replicated four times. The first part of the trial consisted of a one time application of eight different insecticides, and taking pre- and post-counts of thrips at three, seven, and 14 days following treatment (DAT). The second part of the trial consisted of evaluating the rotation of synthetic pyrethroid and organo-phosphate insecticides to determine if one rotation might give better season-long control. The treatments were made with a CO_2 pressurized plot sprayer set to spray at 45 p.s.i. and delivering 24 gallons of water/ac. The center two rows of each plot were used for evaluation. The number of thrips on 10 onion plants in each plot were counted to determine percent control.

The following insecticides were evaluated.

- Penncap M.S. (encapsulated methyl parathion)
- TD 2328-1 (encapsulated diazinon)
  - TD 2341-1]
  - TD 2321-1] Elf Ato Chem numbered insecticides
  - TD 2342-1]
  - Karate - Zeneca Ag insecticide
  - Mustang - FMC - A refined isomer of the insecticide Ammo
  - Methyl parathion

These insecticide treatments were sprayed on June 15 (Table 1).

The initial application of insecticides in the second trial were sprayed on June 25. Three additional applications were applied at 14-day intervals after the initial application was applied (Table 2). The rates applied were as follows:

Karate - 0.025 a.i. (3.3. oz/A)
Mustang - 0.0375 a.i. (3.3 oz/A)
Methyl Parathion - 0.5 a.i. (1.0 pt/A)

Results and Discussion

None of the insecticides in the first experiment were fully effective on onion thrips, but Karate, Mustang and TD 2341-1 gave better control than Penncap MS, the encapsulated formulation of diazinon, or the other numbered compounds (Table 1, Figure 1).

In experiment 2, there was not a clear indication that rotating methyl parathion with Karate or Mustang was beneficial, but, on the other hand, it was not detrimental to overall control and may have a long term beneficial impact (Tables 2 and 3). This is especially important when the seven-day percent control figures are examined as shown in Figure 2.

There was a significant decline in control between the first and second treatments with both Karate and Mustang (Table 2). (The methyl parathion treatments were consistently lower for all treatments.) This decline in control has been experienced by many growers and may be due to insect resistance, or perhaps a change in thrips population dynamics changing from onion thrips to the western flower thrips. The western flower thrip has not been identified on onions in the Treasure Valley during the last part of the growing season, but the observation needs to be re-examined.

Conclusion

There is still a need for a suitable insecticide to alternate with applications of synthetic pyrethroids. There is also a need to re-examine the thrips population in the Treasure Valley during the course of the growing season.

A special thanks is given to the Idaho-Eastern Oregon Onion Committee for funding this project and to Paul Skeen for furnishing the research site.

Table 1. The average number of thrips on 10 onion plants at three, seven, and 14 days after insecticide treatment (DAT). Nyssa, OR. 1993.

Treatment	Rate	Formulation	Formulation material/ac	Precount	3 DAT	7 DAT	14 DAT	Ave.
	lb ai/ac			------------- counts -------------				
Karate	0.025	1.0	3.3 oz	4.9	3.0	0.3	5.6	3.0
Mustang	0.0488	1.5 EW	4.3 oz	4.5	3.9	0.4	5.6	3.3
Mustang	0.0375	1.5 EW	3.3 oz	1.4	5.1	0.2	5.6	3.6
TD 2341-1			1.5 pt	4.7	3.9	0.8	7.5	4.1
TD 2342-1		2 FM	2.0 pt	2.6	4.9	2.4	11.9	6.4
Penncap MS		2 FM	2.0 pt	2.5	6.1	2.1	11.2	6.5
TD 2321-1		40 W	2.0 lbs	4.1	4.7	2.0	13.5	6.7
TD 2328-1		2 FM	2.0 pt	2.8	7.6	3.5	9.3	6.8
Check	-0-	-0-	-0-	4.1	7.8	5.5	14.4	9.2
LSD				ns	ns	2.0	6.4	

Figure 1. The percent of onion thrips controlled by each insecticide treatment. Nyssa, OR. 1993.

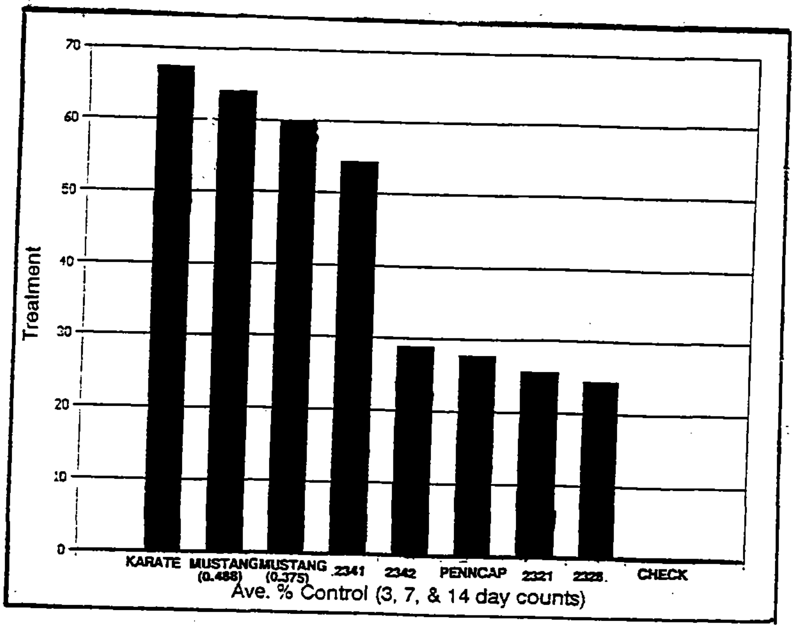


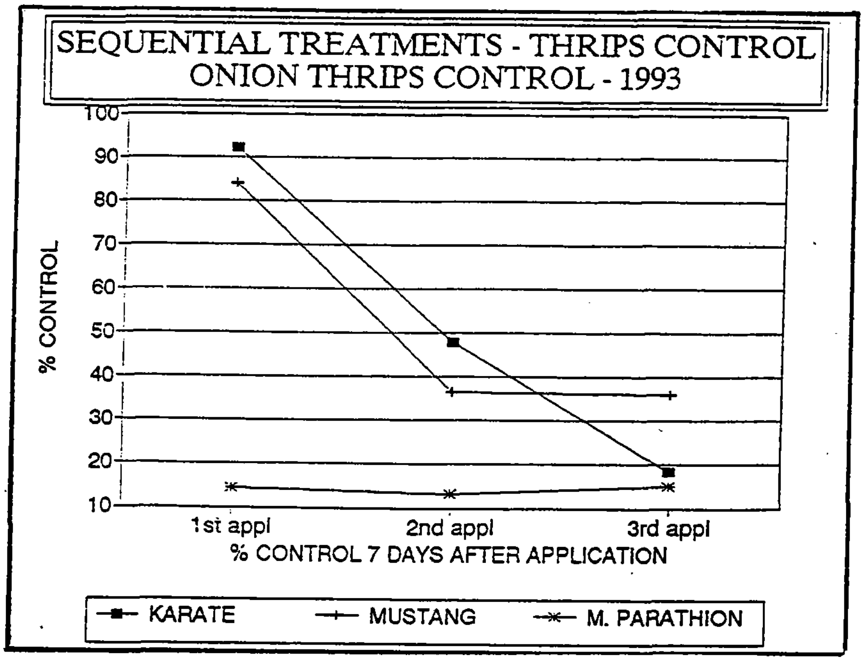
Table 2. The effect of three insecticide applications applied at 14-day intervals on the control of onion thrips 7 and 14 days after treatment (DAT) Nyssa, Oregon, 1993.

Pre-count	Spray 6/25	7 DAT	14 DAT	Spray	7 DAT	14 DAT	Spray	7 DAT	14 DAT
3.9	Karate	0.5	5.3	Karate	2.8	2.8	Karate	3.0	5.1
4.1	Karate	0.3	7.2	Karate	3.7	2.2	Methyl Parathion	6.7	7.9
3.1	Karate	0.2	5.9	Methyl Parathion	2.5	4.0	Karate	2.4	7.0
4.6	Methyl Parathion	2.6	7.3	Methyl Parathion	7.0	5.5	Karate	4.7	5.2
3.0	Mustang	0.8	6.1	Mustang	4.2	2.9	Mustang	3.0	7.0
5.9	Mustang	0.6	5.8	Mustang	3.4	1.7	Methyl Parathion	2.8	3.5
3.7	Mustang	0.5	4.6	Methyl Parathion	7.2	7.1	Mustang	3.2	4.7
3.9	Methyl Parathion	3.9	7.9	Methyl Parathion	7.5	11.9	Mustang	5.6	3.7
4.6	Methyl Parathion	6.4	10.4	Methyl Parathion	11.5	14.4	Methyl Parathion	8.0	7.4

Table 3. Effects of sequential insecticide treatments on average thrips control ranked by efficiency. Nyssa, OR 1993.

Rank	Treatment 1	Treatment 2	Treatment 3	Ave thrips/plant
Karate treatments				
1	Karate	Karate	Karate	3.3
2	Karate	Methyl parathion	Karate	3.7
3	Karate	Karate	Methyl parathion	4.7
4	Methyl parathion	Methyl parathion	Karate	5.4
5	Methyl parathion	Methyl parathion	Methyl parathion	9.7
Mustang treatments				
1	Mustang	Mustang	Methyl parathion	3.0
2	Mustang	Mustang	Mustang	4.0
3	Mustang	Methyl parathion	Mustang	4.6
4	Methyl parathion	Methyl parathion	Mustang	6.8
5	Methyl parathion	Methyl parathion	Methyl parathion	9.7
LSD (0.05)				2.1

Figure 2. Percent thrips control from sequential insecticide treatments. Nyssa, Oregon 1993.



INTEGRATED PEST MANAGEMENT FOR THRIPS
IN SPANISH TYPE ONIONS

Lynn Jensen
Malheur County Extension Office
Oregon State University
Ontario, Oregon

Objective

Determine the efficacy of introduced predator insects in controlling onion thrips on a field scale basis as compared to insecticide control.

Introduction

Onions are one of the most important crops in the Treasure Valley (Malheur County and southwest Idaho). Damage from the onion thrips, *Thrips tabaci* (Lindeman) is the most consistent and economically destructive problem caused by insect pests in this region. There are generally five or more generations per year, beginning in May and ending in August. This season-long need for control and the number of generations per year makes it possible for thrips to develop resistance to the commonly used insecticides. New insecticides and other methods of control are being examined to determine their effectiveness.

Biological control of a pest with a predator has been practiced for centuries, but new understanding of how to regulate and multiply these predators has caused renewed interest in biological control. This is especially true for insects that cause yield reduction but do not affect quality. This is true of onion thrips, which cause foliage damage and yield reduction, but do not affect the quality of the bulb. Onions can tolerate a low level of thrips activity, 15-25 thrips per plant, without impacting yield, but these low levels cannot be maintained without some type of control system. Because of these factors, it was decided that onions might be a prime candidate for some type of biological control program.

Materials and Methods

An experimental site within the city limits of Ontario was selected to conduct research to evaluate predator effectiveness because of its isolation from other onion fields where spray drift may affect the thrips or predator populations. Also, because of the proximity of the field to houses, there was a desire on the part of the grower to not spray any more than necessary.

The field was planted to Yula and Mambo varieties of onions. Fertilizer, onion maggot control, weed control, and other cultural practices were made according to accepted practices for the region.

Twelve sampling sites were randomly selected throughout the field. Each site was two rows wide by 50 feet long. The sites were randomly divided into two groups of six; one group used to monitor the effect of the predators on the thrips population, and the other group used to chemically control the thrips once they reached a threshold averaging 15 thrips per plant. Thrips populations were monitored on a weekly basis by counting total thrips populations on 10 plants in each plot.

The following beneficial insects were released:

Common Name	Scientific Name	Number released per acre per season
Lacewings	Chrysopaoevlata	2,000
-	Amblyseius cucumeris	10,000
Convergent lady beetle	Hippodamia Convergens	2,000
Minute pirate bugs	Onius insidiosus	150

The first release was on May 15 with additional releases made weekly from June 16 through August 9.

Results and Discussion

The trial was designed to compare populations and yields of insecticide-treated onions to those controlled biologically. All areas of the field were under treatments where thrips were controlled, biologically or chemically, and untreated areas were not available. The thrips counts for each plot and count data are listed in Table 1. The threshold level to trigger insecticide spraying was never reached so the insecticide part of the trial was not completed.

Table 1. Onion thrips counts for biological control project. Ontario, Oregon. 1993.

	Sites examined for thrips												
	1	2	3	4	5	6	7	8	9	19	11	12	Ave
Date	thrips/plant												
6 - 14	3.2	0.5	1.1	1.3	0.4	3.4	0.3	0.2	0.4	0.8	0.1	2.5	1.2
6 - 21	12.9	7.9	5.0	4.7	4.2	8.8	2.0	2.9	1.9	4.1	2.3	3.4	5.0
6 - 28	9.3	4.3	3.2	4.3	2.5	3.6	0.9	3.5	0.3	3.3	0.2	1.7	3.0
7 - 6	22.7	4.9	4.8	8.0	2.4	1.9	1.7	1.5	0.4	4.9	2.5	1.8	3.9
7 - 13	11.2	10.0	16.7	5.8	7.3	4.6	6.2	3.3	2.7	2.6	3.1	3.7	6.4
7 - 17	13.7	18.7	10.4	12.2	5.6	12.4	4.0	3.9	1.3	3.7	4.5	4.3	7.9
7 - 27	7.5	6.1	2.3	0.8	1.1	3.5	1.0	1.2	0.9	5.3	3.6	3.6	3.1
8 - 2	8.4	4.6	2.2	1.0	1.9	4.8	10.4	3.2	4.9	11.7	13.5	1.6	5.7
8 - 6	0.4	1.0	0.9	0.4	1.8	2.7	5.5	3.4	4.2	4.3	2.5	6.0	2.8
8 - 17	0.7	2.7	0.6	0.4	0.5	0.4	1.2	3.0	2.7	5.1	7.5	2.2	2.3
Overall average													4.1

The threshold level was not reached until late in the season and then in only two plots for a one-week period. No insecticide treatments were made because of the low levels of thrips throughout the field. Thrips populations were low this year in the Ontario area with most growers spraying only twice instead of the usual 3-4 times. There is a question to what extent the low number of thrips were due to weather and to what extent they were due to beneficial predators. Unfortunately, there was not a reliable way to answer the question because of the constraints of the field experiment. Visible thrips damage was light, even on the red onion variety, which is more attractive to thrips than the yellow variety. Yield samples were not taken.

Conclusions

The low thrips population in the test field could have been due to the beneficial insects, the weather, or a combination of both. The weather conditions for 1993 were cool with record low daily temperatures. Thrips are normally a problem when the temperatures are high. Most onion growers in the Ontario area did not have significant thrips problems in 1993 and only sprayed twice compared with three to four times in a normal year. Because of the constraints caused by the unusually cool temperatures on thrips populations, the effect of treatments for thrips control could not be determined. The results would suggest that the project be redesigned and continued another year.

COMPOSTING CULL ONIONS: A PRELIMINARY REPORT

J. Mike Barnum and Clint Shock
Malheur Experiment Station
Oregon State University
Ontario, Oregon 1993

Introduction

Each year, as a result of the annual processing and packing of approximately 900 million pounds of fresh market onions, Idaho and eastern Oregon onion handlers generate in excess of 90,000 tons of cull onion waste. At present a portion of this waste volume is consumed as livestock feed, a portion is returned to growers fields, and the remainder is buried in pits at various locations around the Treasure Valley. Although the portion of this waste volume currently being buried is not contaminated with any dangerous substances, i.e., pesticide residue or dangerous pathogens, public and governmental concern over the practice is increasing. The primary concern is that burying large volumes of cull onion waste in relatively small areas (pits) creates a situation wherein some of the end products from the decomposition, i.e., nitrates and various organic acids, could eventually contaminate the ground water moving beneath and through the areas where these pits are located.

Although debatable in terms of economic reality, these cull onions have value. One ton of cull onions contains approximately 215 gallons of water, 180 pounds of organic matter, 3 pounds of potassium, 2 pounds of nitrogen, 2 pounds of sulfur, 0.9 pounds of iron, 0.8 pounds of phosphorus, 0.6 pounds of calcium, and trace amounts of other minerals. In terms of maximum available resource conservation and utilization, the three previously described cull onion disposal options fall short. Only two provide for the recovery of value from this product. Spreading the culls over fields provides for reclamation and utilization of the organic matter and fertilizer nutrients; however, because of the potential danger of spreading onion disease pathogens and nematodes, those fields that are or may be used for onion production must be omitted. Feeding the culls to livestock would appear to be an ideal way to achieve maximum reclamation of value except raw onion waste is known to be toxic to cattle and horses when it represents more than 10 percent of their ration. Sheep are the only species of domestic livestock that can effectively utilize the product. Sheep numbers in the northwest have long been on the decline. Under present practices, the value of cull onions disposed of via pit burial is lost.

The underlying principle of pit burial, natural decomposition, may be the key to the development of a fourth option that may allow for recovery and/or utilization of this waste by-product. Composting employs the principals of natural decomposition (aerobic and anaerobic) to transform raw organic materials into useable and often highly desirable soil amendments. If cull onions can be efficiently composted, their nutrient and organic value can be recovered.

The principles of natural aerobic composting have long been used to convert crop residue and other organic waste materials into useable organic materials. Today, because of increased interest in material recycling and the problems associated with solid waste disposal, composting processes are being considered, evaluated, and increasingly used to convert raw, organic solid waste materials into useable products.

In general, providing that certain chemical and physical conditions are met, any organic material can be decomposed (composted) when subjected to the natural processes of aerobic and/or anaerobic decomposition. Depending on the composition, some materials compost better than others. The carbon to nitrogen ratio of onions is relatively high (estimated to be in excess of 50:1). Therefore, the best composting results would be expected if cull onions were mixed with one or more other organic waste materials that contain relatively low amounts of carbon and relatively high amounts of nitrogen, such as manure or alfalfa seed screenings, in order to achieve a carbon to nitrogen ratio in the 15:1 to 30:1 range. Since most compost ingredients are dry, it is usually necessary to add water in order initiate the composting process. Consequently, the cull onion's high water content may prove highly desirable.

Although no specific documentation has been found, an additional benefit that may occur when cull onions are subjected to composting is that undesirable plant pathogens such as *Fusarium oxysporium* may be destroyed as a result of being subjected to high temperature. Temperatures in excess of 150 °F are commonly attained within an aerobic compost pile.

During the fall of 1993, with the support of the Idaho-Eastern Oregon Onion Commission, an experiment exploring the feasibility of composting cull onions was initiated by Malheur Experiment Station personnel. The objective was to evaluate the feasibility and suitability of composting to dispose of cull onions.

Procedure

On October 21 two composting trials (Nos. 1 and 2) utilizing cull onions as a formulation ingredient were initiated at a site approximately 10 miles north of Caldwell, Idaho. The Trial 1 formulation (wet matter basis) consisted of 31.5 tons of cull onions, 21 tons of alfalfa seed screenings, and 5 tons of wheat straw. The Trial 2 formulation (wet matter basis) consisted of 30 tons of cull onions and 35.5 tons of cow manure. In order to minimize the operating costs associated with the commercially manufactured Sittler Compost Turner, which was used to maintain this experiment, both trials were incorporated into a single compost windrow approximately 280 feet long by 8 feet wide by 5 feet high. One-half of the windrow was dedicated to Trial 1, and one-half was dedicated to Trial 2. A tractor mounted front-end loader was used to combine the ingredients used in each trial and to form the original windrow. The Sittler Compost Turner was used to initially mix the ingredients and to perform all succeeding turns.

The approximate volumes of materials combined in each trial were as follows:

Trial No. 1	Cull onions	57.0 cubic yards
	Wheat straw	71.4 cubic yards
	Alfalfa seed screenings	41.4 cubic yards
Trial No. 2	Cull onions	54.3 cubic yards
	Cow manure	50.7 cubic yards

To insure even moisture distribution and adequate aeration following windrow formation, the windrow turner was used to thoroughly mix and reform the windrow. To increase the moisture content in Trial 1, 4,000 gallons of water was applied over the windrow and mixed in using the windrow turner on November 16.

Following initial formation and mixing, the entire windrow was turned at 7 to 10 day intervals from October 1 through December 31. After January 1, 1994, the windrow was turned on a bi-weekly schedule. Compost temperatures at 12, 24, and 36-inch depths at 10 locations within each half (Trial 1 and Trial 2) of the windrow were monitored twice weekly from initiation through January 1994.

On December 17 a representative sample of the composted material from Trial 1 was drawn and dried in a forced air dryer at 100 °F for 120 hours. Following drying, a test for seed viability was conducted by planting three 100 gram composted samples and three 100 gram raw pre-compost alfalfa seed screening samples. (The raw alfalfa seed screening samples were drawn from a sample of the original raw screenings used in these trials.) The three individual samples were broadcast over the surface of three 20-inch-long by 10-inch-wide by 2-inch-deep nursery flats containing a 1½ inch layer of sterile potting mix and covered with an additional one-quarter to one-half inch of potting mix. The flats were irrigated, placed in a controlled environment chamber outfitted with a grow light, and maintained at 70 °F. After 14 days the emerged seedlings in each tray were tallied and identified. On December 31 samples from both trials were drawn and dried as previously described. In early January 1994, the samples from each trial were analyzed for organic matter, nitrogen and carbon content, ash, salts, and pH. Following the same procedure previously described, a second seed viability test was conducted on the sample from Trial 1.

Results

Because these trials are still in progress, only preliminary interim results are reported here.

Following initiation of this experiment, compost temperatures rose quickly in both piles (Figures 1 and 2). Temperatures ranged from a high of 191 °F to a low of 100 °F.

The highest temperatures observed within each trial were recorded on November 13, 23 days after the windrow was formed. Compost temperatures were consistently higher in the onion-screenings-straw compost compared to the onion-manure compost. The mean 12, 24, and 36 inch temperatures from October 25 through December 31 were 146 °F, 155 °F, and 155 °F, respectively, for Trial 1, and 131 °F, 131 °F, and 128 °F, respectively, for Trial 2. The sharp temperature declines on November 30 and December 20 occurred when readings were taken immediately after the windrow was turned. Mean temperatures for Trial 2 stayed below 130 °F throughout December.

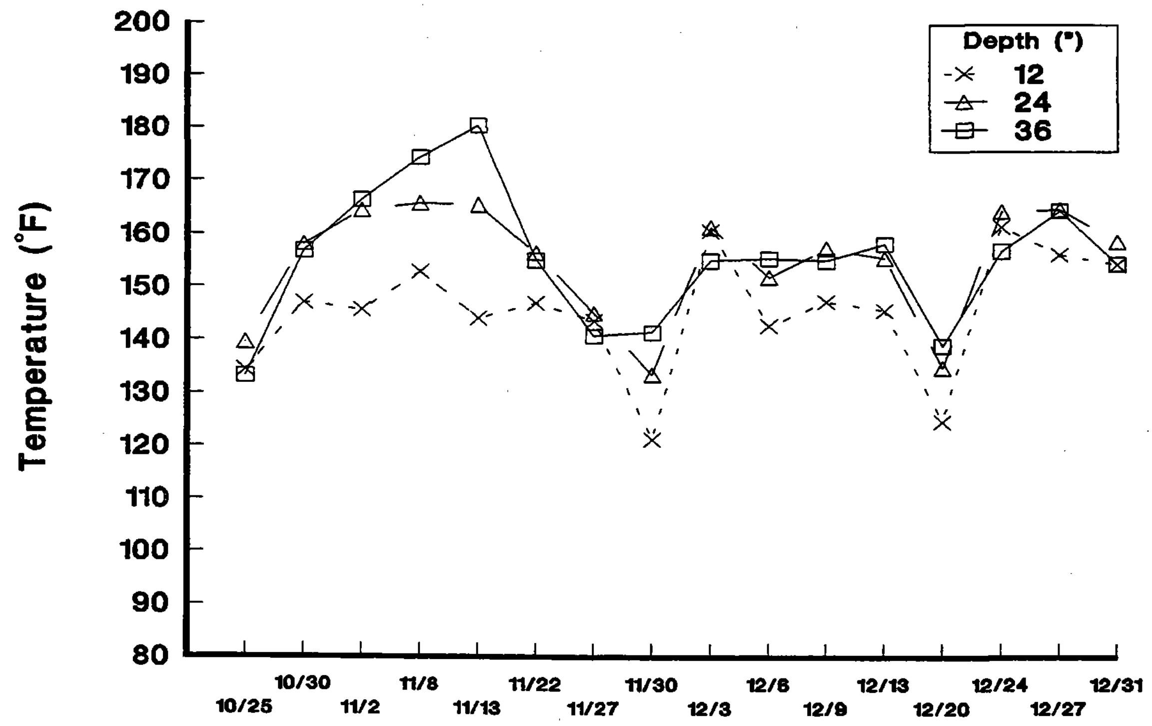


Figure 1. Mean compost temperatures for Trial 1 at 12, 24, and 36 inches of depth from October 25 through December 31, 1993, at Caldwell, ID, as conducted by the Malheur Experiment Station, Oregon State University.

Weekly observations of the material within the windrow showed that decomposition of the cull onion waste was virtually complete in both trials by late November. By the end of December identifiable pieces of onion were difficult to find. Late December observations also showed that considerable change in both texture and particle size of the alfalfa seed screenings and the straw had occurred in Trial 1. The pungency of the offensive, sweet smelling odor, which has been observed during the active phases of previous experiments wherein alfalfa seed screenings have been composted alone, was rarely noticeable in samples from Trial 1. The manure odor, which was obvious in samples from Trial 2 during early November, was indiscernible by early December.

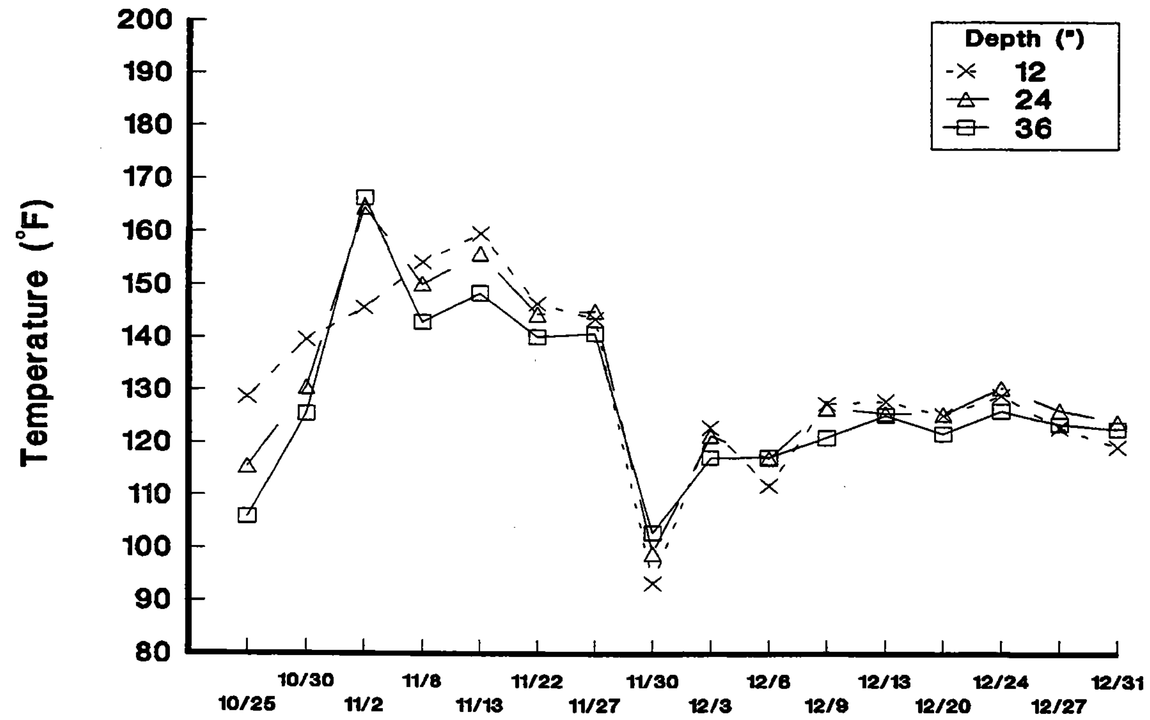


Figure 2. Mean compost temperatures for Trial 2 at 12, 24, and 36 inches of depth from October 25 through December 31, 1993, at Caldwell, ID, as conducted by the Malheur Experiment Station, Oregon State University.

Evaluation and analysis of the data from the seed viability test conducted on samples of compost from Trial 1 and raw pre-composted alfalfa seed screenings showed a highly significant difference in the number of seedlings emerging from equal weights of the two materials (Figure 3).

Analysis of data from field notes and pre- and post-treatment laboratory analyses shows considerable changes in volume, structure, and composition in both trials (Table 1). Similar volume reductions in windrow volume and increases in compost density occurred in both trials. Organic material (OM) reduction was greater in Trial 1 than in Trial 2.

Some degradation of organic material occurred in each trial. The organic material reduction percentage for Trial 1 was slightly greater than for Trial 2. With the exception of nitrogen, fertilizer nutrient content per unit increased in proportion to the reduction in organic material (Table 2).

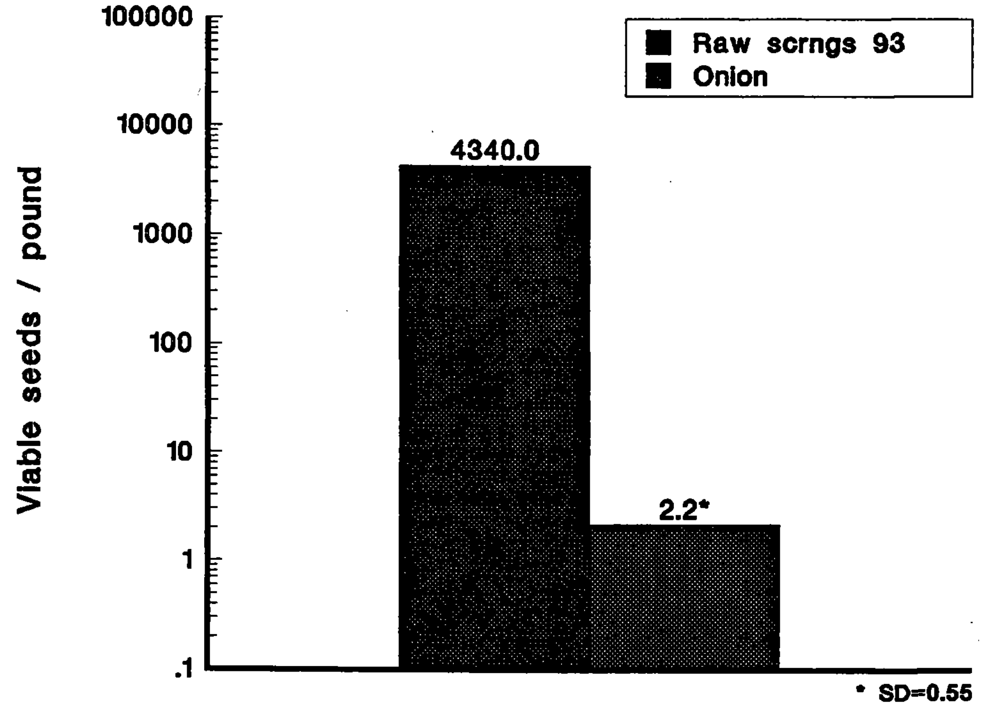


Figure 3. Average number of plant seedlings emerging from 1 pound of compost from Trial 1 compared to the average number of plant seedling emerging from 1 pound of raw alfalfa seed screenings. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Table 1. A comparison of the physical volume and structure of the Trial 1 and Trial 2 sections of the compost windrow at the beginning of the experiment, October 21, to the volume and structure of each section on December 31, 1993, at Caldwell, ID, as conducted by the Malheur Experiment Station, Oregon State University.

	Trial 1		Trial 2	
	Oct 21	Dec 31	Oct 21	Dec 31
Volume (cu yds)	170	94	105	55
Density (lbs/cu yd)	706	918	1247	1269
Percent moisture	51.3	49.24	72.9	50.21
Dry matter (lbs)	58450	43802	35483	34751
Water (lbs)	61570	42490	95452	35044
Ash (lbs)	9151	9151	13056	13056
Organic material (lbs)	49299	34651	22427	21695
OM reduction (%)		29.7		3.3
C:N ratio	13.8	10.5	20.1	14.4

Table 2. A comparison of the percentages, at 100 percent dry matter, of organic material and fertilizer nutrients per unit of the compost formulations for Trials 1 and 2 at the beginning of the experiment, October 21, to the percentages per unit on December 31, 1993, at Caldwell, ID, as conducted by the Malheur Experiment Station, Oregon State University.

	Trial 1		Trial 2	
	Oct 21	Dec 31	Oct 21	Dec 31
	.... % of dry matter			
Organic material	84.3	79.1	63.2	62.4
Nitrogen	3.4	2.3	3.2	1.2
Phosphorus	0.4	0.5	2.2	2.2
Potassium	1.8	2.3	0.8	0.8
Magnesium	0.2	0.3	4.1	4.2
Calcium	0.7	0.9	0.8	0.8
Sodium	0.1	0.2	0.7	0.7
pH		7.0		9.4
Salts (mmhos/cm)		13.2		30.0

Discussion

Aerobic composting should be considered a highly suitable method for the rapid and virtually complete disposal of cull onion waste. The cull onions introduced to the compost were, for all practical purposes, completely decomposed within 30 days. after initiation of the trials. During the first three weeks the whole onions gave considerable bulk to the compost windrow thereby providing for excellent aeration within the pile. As structural breakdown of the onions occurred, windrow core temperatures declined to a level that was approximately equal to or slightly below the 24-inch temperatures. This leveling off of temperature suggests a reduction in the oxygen supply at the windrow core.

The higher temperature attained in Trial 1 compared to Trial 2 may reflect the differences in available oxygen (aeration) levels within the compost material for each trial. The higher temperature in Trial 1 illustrates the importance of the inclusion of a low density, low moisture bulking material such as straw, woodchips, cornstalks, or seed-field chaff to the compost formulation. In Trial 2 the particle size of the manure was relatively small; and as the cull onions physically collapsed, aeration, which is essential to the aerobic process, appears to have been drastically reduced. Comparatively, the straw included in the formulation for Trial 1 broke down relatively slowly thereby providing better aeration.

The high water content of the onion waste proved highly beneficial in that nearly 80 percent of the water required for the formulation in Trial 1 and an overabundance of water for Trial 2 was contained within the onion waste. Because the water contained in the onions was released slowly over the period of several weeks, no runoff or mud problems were encountered. Previous experience has shown that muddy conditions that inhibit equipment operations can be expected whenever appreciable water is applied over a compost windrow on bare soil sites such as the site where this experiment was conducted. Since most of the 18,000 gallons of water required for this experiment was provided by the cull onions, mud was not a problem.

Because of the spherical shape and firmness of the cull onions and previous experience in piling onions with a front-end loader, it was anticipated that during the early stages of the experiment it would be somewhat difficult to keep the onions in the windrow. It was expected that many onions would roll out whenever the windrow was turned. In reality the problem proved to be minor. The mixing and beating effect of the Sittler Compost Turner tended to combine the ingredients so effectively that very few onions rolled out of the windrow. Although not problematic, it was observed that more onions rolled away from the onion-manure mix (Trial 2) than from the onion-alfalfa screening-straw mix (Trial 1).

Considering the annual volume of cull onions and the associated costs and potential environmental consequences of those disposal practices presently being employed, composting offers a highly feasible alternative. If coordinated agricultural waste disposal programs involving various agricultural product waste sources within the Treasure Valley were developed, the supply of cull onion waste would be of primary importance. Such programs might involve the strategic location of compost/disposal sites where various seasonally available organic waste materials could be stock-piled. Through composting these waste materials could be converted to value-added products.

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POTATO HERBICIDE TRIAL

Charles E. Stanger and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, Oregon 1993

Purpose

Hairy nightshade (Solanum saccachoides Sendt.) and wild oats (Avena fatua L.) are troublesome weed species that are difficult to control selectively in potatoes with herbicides commonly used. These weeds left uncontrolled can interfere with harvest operations and reduce tuber yield and quality. Metribuzin (Sencor/Lexone) is a herbicide commonly used as either a preemergence or postemergence treatment to control annual broadleaf weeds and certain species of grasses in Russet Burbank variety of potatoes. Metribuzin is not an effective herbicide for control of wild oats or hairy nightshade. Shepody and Ranger Russet varieties of potatoes are becoming popular choices to grow for processing in the Treasure Valley of Oregon and Idaho. Shepody has been reported to be sensitive to metribuzin. The objectives of these trials were to establish tolerance levels of Ranger Russet, and Shepody potato varieties to metribuzin and tank-mix herbicide combinations of metribuzin plus E-9636 and Frontier herbicides and to determine the effectiveness of tank-mix combinations for control of hairy nightshade, wild oats, and other weeds common to potatoes. Data collected included percent weed control, tuber yield by market grade, and tuber fry quality.

Procedures

Russet Burbank, Ranger Russet, and Shepody potato varieties were planted on May 11 in four separate areas to evaluate herbicides as preemergence and postemergence applications. Seed pieces were planted at a 9-inch drop in rows spaced 36 inches apart. Individual treatment plots were two rows wide and 30 feet long. The previous crop was Stephen's wheat. Following wheat harvest (1992) the straw stubble was mulched, the field chiseled to a depth of 30 inches and the field was bedded in the fall in preparation for planting potatoes in the spring of 1993. Two-hundred lbs/ac of nitrogen and 100 lbs/ac phosphate were broadcast in the fall before deep chiseling. The soils were Owyhee silt loam texture, containing 1.3 percent organic matter, and had a pH of 7.3. The potatoes were irrigated using a solid set sprinkler system.

The postplant preemergence herbicide treatments were applied to Russet Burbank potatoes on May 13 (Table 1). After planting, hilling shovels and Lilliston rolling cultivators were used to hill the planted rows. Herbicides were sprayed as broadcast double-overlap applications over the hilled rows. The potatoes were not cultivated after the preemergence herbicides were applied. An application of 0.75 inches of water by sprinkler irrigation was begun following the application of the preemergence herbicide treatments.

The postemergence herbicides (Tables 3, 4, and 5) were applied to Russet Burbank, Shepody, and Ranger Russet varieties on June 17 to evaluate variety tolerance to herbicides. Weeds were controlled with a preemergence application of Dual, Prowl, and Eptam. The potato foliage was 6-8 inches tall when the postemergence herbicides were applied. Weather conditions when spraying the post treatments were air temperature 72 °F, soil temperature 66 °F, calm wind, clear skies, and dry soil surface. The soil was moist at the 2-inch depth.

All the herbicide treatments were applied with a single wheel bicycle sprayer, 9-foot spray boom with 10-inch spacing between nozzles using teejet fan nozzles size 8002, and spray pressure of 42 psi. Water was applied at a volume of 30.1 gal/acre.

Each herbicide treatment was replicated three times and placed at random in blocks using a randomized complete block experimental design.

The trials were harvested on September 23. Tubers were graded to determine total yield by market grade and size. Twenty tubers for each treatment from all replications were fried to compare tubers for fry quality. Fry color readings were taken from a section of tuber clipped from the stem-end. The clipped section was fried in soybean oil at 375 °F for 2.5 minutes. Fry color readings were determined by measuring light reflectance using a Model 577 Photovolt Reflectance Meter. Stem-ends with a reflectance reading of 25.3 or less were considered to be sugar-ends and are unacceptable for processing. Tuber yield and market grades were obtained from tubers harvested from each replicated plot (2 rows X 30 feet). Number 1 tubers were graded in size categories weighing 4-8 oz, 8-12 oz and larger than 12 oz. Undersize tubers were less than 4 oz. Yield and fry quality data are included by potato variety in tables 2, 3, 4, and 5.

Results

The preemergence herbicide treatments to Russet Burbank potatoes were evaluated for crop tolerance, weed control, and tuber yields (Tables 1 and 2). Tuber yields from postemergence trials are reported in tables 3, 4, and 5.

Ranger Russet, Shepody, and Russet Burbank potato varieties were tolerant of all herbicide treatments including rates and time of application. Tuber yields and size of Russet Burbank were significantly reduced in untreated check plots and in plots treated with herbicides at reduced rates not effective for control of hairy nightshade. Higher tuber yield was obtained from two- or three-way tank-mix combination treatments including herbicides E-9636, Lexone, Frontier, Prowl, Dual, or Eptam. Minimum effective rate of E-9636 for nightshade control was 0.03125 lbs ai/ac. Fry quality was not affected by herbicide treatments. Sugar-end tubers occurred with the Russet Burbank variety, but neither fry color nor percent sugar-ends in treated plots was significantly different from tubers in the untreated check. Shepody and Ranger Russet tubers fried significantly lighter in color and were superior in tuber yield and quality compared to Russet Burbank (Tables 2, 3, 4, and 5).

The herbicide E-9636 at 0.01563 lbs ai/ac controlled 80-90 percent of the pigweed, sowthistle, barnyardgrass, and 91 percent of the early season nightshade when applied preemergence. At this reduced rate E-9636 did not persist under sprinkler irrigation to control later germinating hairy nightshade. Higher rates of E-9635 (0.03125 lbs ai/ac) applied alone resulted in better late season control of hairy nightshade. E-9636 did not control lambsquarters effectively at the lower rates. Frontier herbicide gave good control of pigweed, hairy nightshade, lambsquarters, barnyardgrass, and wild oats at the 2.5 lbs ai/acre rate. It was less effective on all weed species at lower rates. The herbicide Frontier did not control sowthistle.

Tank-mix combinations of Lexone plus E-9636 applied at a rate of 0.25 + 0.03125 lbs ai/ac postplant preemergence to Russet Burbank potatoes controlled all broadleaf weed species and 93 percent of the grass weeds when treatments were evaluated in late June (Table 1). Some hairy nightshade plants did emerge late and grew to reinfest treated plots by harvest time. Eptam in tank-mix combination with Lexone plus E-9636 enhanced the control of hairy nightshade, which left these treated plots weed free at harvest. Three-way tank mixes of Prowl, Dual and Eptam also resulted in weed-free plots at harvest. Eptam was an excellent addition to all treatments for improved control of hairy nightshade.

Both Ranger Russet and Shepody varieties yielded more total tubers with higher percent number one's and better fry colors than Russet Burbank. Herbicides did not reduce tuber yields, tuber quality, or fry quality when treated plots were compared to untreated check plots for each potato variety (Tables 2, 3, 4, and 5).

Table 1. Percent crop injury and weed control ratings from herbicide treatments applied to Russet Burbank potatoes as postplant preemergence applications. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Weed Control																							
		Pigweed				Hairy nightshade				Lambsquarters				Sow thistle				Barnyardgrass				Wild oats			
Herbicides	Rate	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A
	lbs ai/ac	%																							
E 9636	0.0157	96	98	98	97	93	90	90	91	65	70	70	67	95	90	90	92	85	85	80	83	80	75	75	76
E 9636	0.0238	100	98	98	98	99	98	99	98	70	75	75	73	95	98	95	96	85	90	85	87	85	85	80	83
E 9636	0.03125	100	100	100	100	100	99	99	99	85	80	80	82	100	100	100	100	95	90	93	93	90	93	93	92
E 9636 + Lexone	0.0157 + 0.125	100	100	100	100	99	100	99	99	99	96	98	96	100	100	100	100	90	85	85	87	95	98	95	96
E 9636 + Lexone	0.0238 + 0.1875	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	95	98	98	97	99	96	98	97
E 9636 + Lexone	0.03125 + 0.25	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	99	100	99	99	99	99	99	99
E 9636 + Lexone + Eptam	0.03125 + 0.25 + 3.0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
E 9636 + Lexone + Eptam	0.03125 + 0.25 + 1.0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
E 9636 + Lexone + Dual	0.03125 + 0.25 + 2.0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
E 9636 + Lexone	(0.0157 + 0.125)[1]	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Prowl + Dual + Eptam	1.5 + 2 + 2	100	100	100	100	100	100	100	100	100	100	100	100	70	60	60	63	100	100	100	100	100	100	100	100
Frontier	1.0	95	98	95	96	88	92	90	90	85	90	85	86	35	40	30	35	98	98	98	98	96	98	96	97
Frontier	1.25	99	98	99	98	93	90	95	93	88	90	90	89	40	30	35	35	98	98	99	98	96	98	98	97
Frontier	2.5	100	100	100	100	96	98	96	97	98	95	95	96	40	40	40	40	100	100	100	100	100	100	100	100
Eptam	4.5	96	98	94	96	99	99	99	99	98	98	98	98	20	15	15	16	99	99	99	99	95	93	95	94
Frontier + Prowl	1.25 + 1.5	100	100	100	100	98	98	98	98	100	100	100	100	40	45	40	42	100	100	100	100	100	100	100	100
Dual + Prowl	2.0 + 1.5	100	100	100	100	99	98	98	98	100	100	100	100	45	40	35	40	100	100	100	100	100	100	100	100
Check	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Herbicides applied preemergence and postemergence at rate listed. Postemergence treatment evaluated on June 10. Preemergence plus postemergence treatment evaluate on June 10 and June 30. Percent weed control for pre + post treatments are for June 30 evaluations. Ratings: 0 = no effect, 100 = all plants killed. Russet Burbank was tolerant to all treatments. Injury ratings for all treatments was 0.

Planting and Spraying Information:

- Russet Burbank planted on May 11 and hilled May 12.
- Postplant preemergence treatments applied on May 13.
- Sprinkle irrigated with 3/4 inch water on May 13.
- Spray pressure 45 psi, water volume 21 gal/ac, double overlap broadleaf application.
- Teejet fan nozzles size 8002.
- Postemergence treatment applied on June 17. Potato foliage 6" high. Used same spray equipment and procedure as describe for preemergence application.

Table 2. Tuber yields and fry quality data from Russet Burbank potato variety treated with herbicides applied as postplant preemergence applications. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Tuber yield							Fry Quality[2]		
	Rate	Tot	No. 1's	>12oz	8-12oz	4-8oz	<4oz	No. 2's			
Herbicides	cwt/ac	%	cwt/ac	cwt/ac	cwt/ac	cwt/ac	cwt/ac	cwt/ac	Color	# Darkends	% Darkends
E 9636	0.0157	409	78	115	108	97	37	52	33	0	0
E 9636	0.0238	480	76	98	136	129	58	59	31	0	0
E 9636	0.03125	510	72	118	120	127	90	55	35	1	1.67
E 9636 + Lexone	0.0157 + 0.125	477	71	93	116	132	81	55	31	0	0
E 9636 + Lexone	0.0238 + 0.1875	467	70	104	119	104	76	64	30	0	0
E 9636 + Lexone	0.03125 + 0.25	509	72	127	123	115	81	63	34	1	1.67
E 9636 + Lexone + Eptam	0.03125 + 0.25 + 3.0	466	75	119	121	109	76	41	33	0	1.67
E 9636 + Lexone + Prowl	0.03125 + 0.25 + 1.0	494	74	107	132	125	57	63	32	1	1.67
E 9636 + Lexone + Dual	0.03125 + 0.25 + 2.0	465	69	94	110	118	74	69	34	1	1.67
E 9636 + Lexone	0.0157 + 0.0125[1]	495	74	110	122	135	91	37	31	0	0
Prowl + Dual + Eptam	1.5 + 2.0 + 2.0	476	70	94	109	128	100	45	32	0	0
Frontier	1.0	488	71	94	123	128	75	68	33	0	0
Frontier	1.25	471	70	93	116	122	88	52	31	0	0
Frontier	2.50	462	74	111	113	118	64	56	33	0	0
Eptam	4.5	400	69	88	76	112	79	45	32	1	1.67
Frontier + Prowl	1.25 + 1.5	460	71	97	121	107	79	56	31	0	0
Dual + Prowl	2.0 + 1.5	501	71	100	130	125	92	54	34	0	0
Check	-	314	64	57	66	79	51	61	31	1	1.67
LSD (0.05)		59	6.2	26	39	26	23	24	-	-	-
CV (%)		6	3	9	12	8	11	14	-	-	-

[1] Herbicides applied preemergence and postemergence at rates listed applied each application.

[2] Twenty tubers fried from each replication. Date reported as average of 3 replications.

Table 3. Tuber yield and fry quality data of Shepody potato variety treated with herbicides applied as postemergence application. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Tuber yields							Fry Quality[1]		
	Rate	Total	No. 1's	>12oz	8-12oz	4-8oz	<4oz	No. 2's			
Herbicides	lbs ai/ac	cwt/ac	%	cwt/ac	cwt/ac	cwt/ac	cwt/ac		Color	#Darkends	%Darkends
E 9636	0.0157	409	77	137	89	88	47	48	49	0	0
E 9636	0.03125	415	80	187	93	52	42	41	49	0	0
E 9636	0.0625	408	77	158	102	56	46	46	49	0	0
E 9636 + Lexone	0.0157 +	453	77	202	87	60	48	57	51	0	0
E 9636 + Lexone	0.03125 +	425	77	170	95	64	48	48	50	0	0
E 9636 + Lexone	0.0625 + 0.5	424	77	172	92	63	50	47	50	0	0
Check	-	425	76	162	95	65	53	50	49	0	0
LSD (0.05)		46	ns	20	ns	18	ns	ns	-	-	-
CV (%)		6	3	4	6	15	20	29	-	-	-

[1] Twenty tubers were fried from each replication. Data reported as average of 3 replications.

Table 4. Tuber yields and fry quality data of Ranger Russet potato variety treated with herbicides applied as postemergence applications. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Tuber yields									
	Rate	Total	No. 1's	>12oz	8-12oz	4-8oz	<4oz	No. 2's	Fry Quality[1]		
Herbicides	lbs ai/ac	cwt/ac	% cwt/ac	cwt/ac	cwt/ac	cwt/ac	cwt/ac	cwt/ac	Color	# Darkends	% Darkends
E 9636	0.0157	488	86	146	156	118	35	33	45	0	0
E 9636	0.03125	494	83	141	151	118	57	27	47	0	0
E 9636	0.0625	471	79	134	127	112	54	45	46	0	0
E 9636 + Lexone	0.0157 + 0.125	479	84	152	137	115	37	39	46	0	0
E 9636 + Lexone	0.03125 + 0.25	481	86	140	156	115	40	29	45	0	0
E 9636 + Lexone	0.03125 + 0.5	479	85	145	147	115	46	26	47	0	0
Check	-	482	86	144	150	122	52	14	45	0	0
LSD (0.05)		ns	5	ns	28	ns	12	18	-	-	-
CV (%)		4	3	4	6	9	9	18	-	-	-

[1] Twenty tubers were fried from each replication. Data reported as average of 3 replications.

Table 5. Tuber yield and fry quality of Russet Burbank potato variety treated with herbicides applied as postemergence applications. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment		Tuber yield									
	Rate	Total	No. 1's	>12oz	8-12oz	4-8oz	<4oz	No. 2's	Fry Quality[1]		
Herbicides	lbs ai/ac	cwt/ac	%	cwt/ac	cwt/ac	cwt/ac	cwt/ac	cwt/ac	Color	# Darkends	% Darkends
E 9636	0.0157	406	75	91	103	109	68	35	32	0	0
E 9636	0.03125	413	75	99	107	105	67	34	31	0	0
E 9636	0.0625	421	71	91	98	112	91	29	30	1	1.67
E 9636 + Lexone	0.0157 + 0.125	405	74	96	98	107	69	37	31	0	0
E 9636 + Lexone	0.03125 + 0.25	407	75	102	97	107	67	34	31	0	0
E 9636 + Lexone	0.0625 + 0.5	406	73	91	103	101	78	33	31	0	0
Check	-	403	71	72	96	120	81	34	30	10	1.67
LSD (0.05)		ns	ns	16	ns	15	20	ns	-	-	-
CV (%)		3	4	6	7	5	9	13	-	-	-

[1] Twenty tubers were fried from each replication. Data reported as average of 3 replications.

IRRIGATION MANAGEMENT FOR POTATO VARIETIES; VARIETY TOLERANCE TO DEFICIT IRRIGATION, 1993 TRIAL

Clint Shock, Erik Feibert, and Monty Saunders
Malheur Experiment Station
Oregon State University
Ontario, Oregon

Introduction

Potato producers in eastern Oregon's part of the Treasure Valley have new market opportunities to produce and sell Shepody, Frontier Russet, and Ranger Russet varieties to potato processors. Producers need to have information on how best to irrigate these varieties. Do Shepody, Frontier Russet, Ranger Russet, and new varieties in the Oregon statewide variety development program need less water and can they tolerate greater water stress than Russet Burbank? Processing company field representatives have suggested lower irrigation rates for Shepody potatoes.

Procedures

Varieties were grown uniformly with limited N additions. Twenty pounds of N/ac and 100 pounds of P_2O_5/ac as monoammonium phosphate, plus 10 pounds of Z/ac as zinc sulphate, were broadcast in the fall of 1992 on an Owyhee silt loam previously planted to spring wheat at the Malheur Experiment Station. A soil sample taken from the top foot on April 15, 1993 showed a pH of 7.3, 1.5 percent organic matter, 8 CEC, 8 ppm nitrate-N, 7 ppm ammonium-N, 26 ppm phosphorus, 569 ppm potassium, 2,900 ppm calcium, 280 ppm magnesium, 257 ppm sodium, 7.1 ppm zinc, 7.2 ppm iron, 14.4 ppm manganese, 1.3 ppm copper, 7 ppm sulfur, and 0.6 ppm boron. The field was bedded into 36-inch hills in the spring of 1993. Prowl at 1 lb ai/ac and Dual at 2 lbs ai/ac were sprayed on May 6 and incorporated during planting. Two-ounce seed pieces were planted May 7 at 9-inch spacing. On May 14, urea at 45 lbs N/ac was sidedressed with Thimet 20G at 3 lbs ai/ac. Bravo 500 was applied at 0.6 pint ai/ac for preventive control of leaf fungi on June 25. Uniroyal ZKP (0-16-9, 1 percent Zn) was simultaneously applied at 2 qts/ac.

Potato irrigation treatments were the main plots with each treatment replicated five times (Table 1). The seven potato varieties were subplots within the main plots (Table 2). Plots were 40 feet by 40 feet, and each plot was irrigated individually based on its soil water potential using a sprinkler head covering 90 degrees at each corner of the plot. Water application rate was 0.39 inches per hour.

Two granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200, Irrometer Co., Riverside, CA) were offset six inches from the hill top and centered eight inches below the hill surface (top of GMS was 6 inches from soil surface), and two GMS were offset six inches from the hill top and centered 20 inches below the hill surface (top of GMS was 18 inches from soil surface). These sensors were used to measure soil water potential in each plot. GMS had been previously calibrated to soil water potential. Sensors were read five times per week from June 10 to September 4. Soil water potential data from the first foot of soil was used as the criteria for irrigation decisions (Table 1).

Table 1. Irrigation treatments tested and actual water use at the Malheur Experiment Station, OSU, 1993.

Treatment Number	Irrigation Criteria	Irrigation Intensity	Number of Irrigations	Water Applied
				ac-in
1.	- 60 kPa	Replace water deficit all season	16	16.1
2.	- 80 kPa	Replace water deficit	10	10.0
3.	- 80 kPa	Replace 70% of water deficit	12	10.2
4.	- 80 kPa	Replace 50% of water deficit until stolon hooking, replace 70% of the water deficit for the next 6 weeks, then 50% of the deficit	16	10.2

Potato evapotranspiration (ET_c) was determined by an AgriMet weather station at the Malheur Experiment Station assuming May 30 emergence and June 28 row closure.

Due to an unusually wet winter and spring the soil water potential was -16 kPa in the second foot of soil and -38 kPa in the first foot on June 14. This indicated a substantial amount of water in the profile that could be available to the plant by a combination of upward capillary movement and root absorption. This resulted in the GMS responding slower than expected from the (ET_c) data. Consequently, less water than the accumulated ET_c was required to keep the surface soil wet. It was decided to limit water applications to 1.2 inches when GMS data indicated irrigations were necessary. The water applications for treatments 2, 3, and 4 were based on 1.2 inches of water applied being 100 percent.

The soil was thoroughly sampled at one foot increments to a 6 foot depth both before planting and after harvest. Soil samples were analyzed for nitrate and ammonium nitrogen. Nitrogen supply at planting and residual available nitrogen at harvest were calculated. Irrigation water was assumed to contribute 1.35 lbs N/ac/inch.

Petiole samples were collected every two weeks from June 15 to August 4 from Russet Burbank plants in the treatment 1 plots and analyzed for nitrate-N as a guide to help keep nitrogen non-limiting. Due to low petiole nitrate levels the trial received thirty lbs of N/ac as uran on July 5, July 20, August 16, and 20 lbs N/ac, also as uran, was applied on August 4.

All tubers were harvested September 29. Tubers were evaluated for yield and grade. A 40 tuber sample of each variety from each plot was stored and evaluated for specific gravity and fry color in late October.

Results and Discussion

Petiole nitrate levels were below the adequate range all season for Russet Burbank, according to established guidelines (Jones and Painter, 1974) (Figure 1).

The amount of irrigation water applied to all treatments (including rainfall) was close to or less than potato ET_c, 19 ac-in for 1993, (Figure 1). Soil water potential over time differed between irrigation treatments, and indicates the increasing level of water stress in accordance with the treatments both in the first and second foot of soil (Figures 2 to 5). Due to a wet winter and an unusually wet spring, the soil water potential in the second foot of soil was initially wetter than in the first foot of soil (Figures 2 to 5). However, by early July the soil water potential in the second foot of soil became drier than -60 kPa (drier than in the first foot of soil) and remained so for the rest of the season for all treatments, suggesting that nitrate leaching potential was minimal.

The varieties COO 83008-1 and Russet Burbank were among the most productive of marketable tubers (Table 2). Russet Burbank had the highest total yields in 1993, along with one of the highest yields of unmarketable undersized tubers. Total yield and total US Number One tuber yield were significantly reduced by water stress over all varieties. The varieties Russet Burbank and NDTX 8-731-1R were the most productive of US Number One tubers in 1993. Tuber grade distribution was strongly influenced by variety (Table 3). Irrigation treatment had little effect on tuber grade distribution in 1993, a relatively cool year.

Tuber specific gravity and stem-end fry color were strongly influenced by variety but varied less by irrigation treatment (Table 4). Russet Burbank and Frontier Russet had the darkest stem-end fry color out of storage, while COO 83008-1 had the lightest stem-end fry color. Ranger Russet, AO 82611-7, and Shepody had stem-end fry color intermediate between Russet Burbank and COO 83008-1.

The amounts of nitrate-N and ammonium plus nitrate-N in the top 2 feet of soil in the fall were higher than the spring levels, and similar for all irrigation treatments (Figures 7 and 8). Plant growth requires an extraction of plant-available forms of nitrogen from the soil, and for potatoes, most of the extraction is from the surface 30 to 60 cm of soil. Since the crop received only 110 pounds N/acre, we might expect that much of the ammonium and nitrate in the upper part of the soil profile at planting would be extracted by harvest (approximately 155 pounds N/acre with the harvest of 500 cwt/ac); however, in all irrigation treatments there was more nitrate-N and ammonium-N in the profile at harvest than at planting (Table 5 and 6, Figures 7 and 8), suggesting that organic matter mineralization, crop residue decomposition, nitrogen contamination in the irrigation water, and other undefined sources provided large inputs of available-N during the growing season. The accumulation of available N in the soil profile is also another indication that nitrate leaching was minimal.

Conclusions

The 1992 and 1993 results demonstrate that optimum tuber yield, grade, and quality can be achieved without nitrate leaching through careful irrigation management. Available forms of nitrogen accumulated in the upper part of the profile. Precise irrigation management can be achieved through irrigation before the soil water potential reaches the critical level (-60 kPa for silt loam soils in Malheur County), and through full replacement of crop evapotranspiration. All varieties lost total yield and yield of US Number One tubers with water stress. In addition, this trial underlines the need to define and measure other sources of nitrogen available to the plant.

Acknowledgements

The support of the Oregon Potato Commission is gratefully acknowledged.

Literature cited

Jones, J.P. and Painter, C.G., 1974. Tissue analysis: A guide to nitrogen fertilization of Idaho Russet Burbank Potatoes. University of Idaho, College of Agriculture, Cooperative Extension Service, Agricultural Experiment Station, Current information series # 240, June 1974.

Table 2. Yield and grade response of seven potato cultivars to four irrigation treatments. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Irrigation treatment	Potato yield by market grade											Total yield
		US Number One				US Number Two				Total marketable	Rot	Undersize	
		4-6 oz	6-10 oz	> 10 oz	total	4-6 oz	6-10 oz	> 10 oz	total				
		cwt/ac											
R. Burbank	1	139.8	143.0	84.5	367.4	19.3	27.8	21.1	68.2	435.5	0.3	105.9	541.8
	2	123.9	167.2	70.5	361.6	21.1	19.6	8.2	48.9	410.5	0.8	94.7	506.0
	3	121.4	152.4	53.2	326.9	28.9	37.1	14.7	80.7	407.6	0.0	96.3	503.9
	4	130.3	155.1	62.0	347.3	25.7	20.8	9.8	56.4	403.7	0.4	97.2	501.2
	Average	128.9	154.4	67.6	350.8	23.8	26.3	13.5	63.6	414.3	0.4	98.5	513.2
Shepody	1	33.4	98.1	192.7	324.3	15.1	27.0	42.5	84.6	408.8	1.7	17.5	428.0
	2	26.8	86.7	186.1	299.7	14.8	28.2	36.8	79.8	379.5	1.8	17.7	399.1
	3	29.9	80.2	209.2	319.3	10.3	22.6	46.9	79.8	399.1	1.6	18.0	418.7
	4	36.0	85.6	183.9	305.5	10.4	16.0	30.4	56.8	362.3	0.9	24.7	387.9
	Average	31.5	87.7	193.0	312.2	12.7	23.5	39.2	75.3	387.4	1.5	19.5	408.4
F. Russet	1	64.9	104.3	98.1	267.2	7.6	14.8	25.3	47.6	314.8	2.1	58.4	375.4
	2	69.9	106.8	81.0	257.6	12.1	14.1	16.4	42.6	300.2	0.6	67.1	367.9
	3	63.8	102.9	77.6	244.3	14.4	16.1	11.6	42.1	286.4	1.3	62.9	350.6
	4	60.0	104.2	74.5	238.8	7.7	7.3	21.6	36.6	275.3	1.3	58.1	334.8
	Average	64.7	104.6	82.8	252.0	10.5	13.1	18.7	42.2	294.2	1.3	61.6	357.2
R. Russet	1	106.3	116.6	45.4	268.3	20.7	20.6	9.9	51.2	319.6	0.7	80.4	400.7
	2	96.5	106.5	35.3	238.3	20.9	19.1	9.0	48.9	287.2	0.0	85.8	373.0
	3	80.6	97.4	30.1	208.2	18.5	20.1	12.3	50.9	259.1	0.4	89.7	349.1
	4	90.8	95.0	26.5	212.3	18.8	16.0	7.2	41.9	254.3	1.3	84.9	340.4
	Average	93.6	103.9	34.3	231.8	19.7	19.0	9.6	48.2	280.1	0.6	85.5	365.8
AO 82611-7	1	60.4	112.8	150.3	323.4	15.5	32.9	40.5	88.9	412.3	1.3	42.7	456.3
	2	59.1	123.3	125.5	307.9	19.0	27.2	44.3	90.5	398.4	0.6	45.5	444.5
	3	48.1	113.8	131.0	292.9	15.1	25.8	27.8	68.7	361.6	0.0	37.5	399.1
	4	52.9	118.5	117.4	288.8	20.6	26.1	30.1	76.8	365.6	0.0	41.5	407.1
	Average	55.1	117.1	131.1	303.3	17.6	28.0	35.7	81.2	384.5	0.5	41.8	426.8
COO 83008-1	1	31.9	83.0	205.9	320.8	10.0	38.1	91.4	139.5	460.3	1.2	18.8	480.3
	2	22.8	81.0	188.7	292.6	13.5	45.8	85.7	145.0	437.5	0.1	13.2	450.8
	3	18.8	74.2	191.8	284.8	12.8	38.9	71.1	122.9	407.6	0.4	11.6	419.7
	4	16.3	87.5	199.0	302.9	16.7	41.7	80.5	138.9	441.8	1.5	15.4	458.6
	Average	22.5	81.4	196.4	300.3	13.3	41.1	82.2	136.6	436.8	0.8	14.8	452.4
NDTX 8-731-1R	1	51.4	144.0	242.0	437.3	2.4	5.8	13.4	21.6	458.9	0.3	35.0	494.2
	2	38.0	105.5	210.0	353.5	5.6	10.1	25.5	41.1	394.6	1.3	30.4	426.3
	3	43.3	107.2	201.5	352.0	3.3	8.5	12.8	24.7	376.7	0.2	30.5	407.4
	4	45.0	113.9	164.5	323.4	2.1	3.8	15.2	21.1	344.5	0.0	35.7	380.2
	Average	44.4	117.7	204.5	366.6	3.4	7.1	16.7	27.1	393.7	0.5	32.9	427.0
All varieties	1	69.7	114.5	145.6	329.8	12.9	23.9	34.9	71.7	401.5	1.1	51.2	453.8
	2	62.4	111.0	128.2	301.6	15.3	23.4	32.3	71.0	372.6	0.7	50.6	423.9
	3	58.0	104.0	128.0	289.8	14.8	24.2	28.2	67.1	356.9	0.6	49.5	406.9
	4	61.6	108.5	118.3	288.4	14.6	18.8	27.8	61.2	349.6	0.8	51.1	401.5
LSD (0.05) Irrig.		ns	ns	8.2	17.7	ns	7.2	ns	ns	21.7	ns	ns	26.5
LSD (0.05) Var.		8.0	14.0	22.3	27.9	4.1	5.1	9.2	13.2	31.5	0.9	7.2	32.5
LSD (0.05) Irr X Var		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 3. Market grade distribution response of seven potato cultivars to four irrigation treatments. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Irrigation treatment	Potato market grade distribution										
		US Number One				US Number Two				Total marketable	Rot	Undersize
		4-6 oz	6-10 oz	>10 oz	total	4-6 oz	6-10 oz	>10 oz	total			
		%										
R. Burbank	1	25.9	26.4	15.6	67.8	3.5	5.1	3.9	12.5	80.3	0.1	19.6
	2	24.5	33.1	13.9	71.4	4.2	3.9	1.6	9.7	81.1	0.2	18.7
	3	24.1	30.2	10.6	65.0	5.7	7.2	2.9	15.9	80.8	0.0	19.2
	4	26.1	31.0	12.3	69.3	5.1	4.1	1.9	11.2	80.5	0.1	19.4
	Average	25.1	30.2	13.1	68.4	4.6	5.1	2.6	12.3	80.7	0.1	19.2
Shepody	1	7.9	23.7	44.8	76.5	3.4	6.1	9.5	19.0	95.5	0.3	4.2
	2	6.7	21.7	46.7	75.0	3.7	7.1	9.2	20.0	95.1	0.5	4.4
	3	7.6	20.3	48.5	76.5	2.6	5.4	10.8	18.8	95.3	0.4	4.4
	4	9.3	22.2	47.8	79.4	2.5	4.1	7.6	14.2	93.6	0.3	6.2
	Average	8.0	22.0	47.0	77.0	3.0	5.6	9.3	17.9	94.9	0.3	4.8
F. Russet	1	17.5	28.0	25.7	71.2	2.0	3.9	6.6	12.6	83.8	0.6	15.7
	2	18.9	29.0	22.0	70.0	3.3	3.8	4.5	11.6	81.5	0.2	18.3
	3	18.3	29.5	22.2	70.0	4.2	4.5	3.2	12.0	82.0	0.4	17.7
	4	18.0	30.9	22.3	71.2	2.3	2.2	6.5	11.0	82.2	0.4	17.4
	Average	18.2	29.4	23.0	70.6	3.0	3.6	5.2	11.8	82.4	0.4	17.3
R. Russet	1	26.8	28.2	10.7	65.6	5.2	5.0	2.5	12.7	78.3	0.2	21.5
	2	26.2	28.4	9.2	63.8	5.5	5.0	2.3	12.8	76.6	0.0	23.4
	3	23.0	27.9	8.7	59.6	5.3	5.7	3.3	14.4	73.9	0.1	26.0
	4	26.7	27.7	7.7	62.1	5.9	4.6	2.4	13.0	75.1	0.3	24.6
	Average	25.7	28.0	9.1	62.8	5.5	5.1	2.7	13.2	76.0	0.1	23.9
AO 82611-7	1	13.3	24.7	33.1	71.1	3.4	7.2	8.8	19.4	90.5	0.3	9.2
	2	13.3	27.9	28.2	69.4	4.2	6.1	10.0	20.2	89.6	0.1	10.3
	3	12.0	28.4	33.2	73.5	3.8	6.4	6.8	17.0	90.6	0.0	9.4
	4	13.1	29.1	28.8	71.0	5.0	6.4	7.4	18.7	89.7	0.0	10.3
	Average	12.9	27.5	30.8	71.2	4.1	6.5	8.2	18.8	90.1	0.1	9.8
COO 83008-1	1	6.6	17.3	43.0	66.9	2.1	8.0	18.9	29.0	95.9	0.2	3.9
	2	5.1	18.2	41.7	65.1	3.0	10.2	18.7	31.9	97.0	0.0	2.9
	3	4.5	17.5	46.0	68.0	3.0	9.4	16.7	29.1	97.1	0.1	2.7
	4	3.6	19.1	43.2	65.9	3.7	9.2	17.5	30.5	96.4	0.3	3.3
	Average	5.0	18.0	43.5	66.5	3.0	9.2	18.0	30.1	96.6	0.2	3.2
NDTX 8-731-1R	1	10.6	29.2	48.7	88.5	0.5	1.2	2.7	4.3	92.8	0.1	7.1
	2	9.0	24.6	48.9	82.5	1.3	2.5	6.2	10.0	92.5	0.3	7.2
	3	10.6	26.4	49.3	86.3	0.8	2.1	3.1	5.9	92.2	0.0	7.8
	4	12.2	29.8	43.0	85.0	0.6	1.0	3.7	5.2	90.2	0.0	9.8
	Average	10.6	27.5	47.5	85.6	0.8	1.7	3.9	6.4	91.9	0.1	8.0
All varieties	1	15.5	25.4	31.6	72.5	2.9	5.2	7.6	15.6	88.2	0.2	11.6
	2	15.1	26.3	29.6	70.9	3.6	5.5	7.5	16.5	87.4	0.2	12.4
	3	14.3	25.8	31.2	71.3	3.6	5.8	6.7	16.1	87.4	0.1	12.5
	4	15.6	27.1	29.3	72.0	3.6	4.5	6.7	14.8	86.8	0.2	13.0
LSD (0.05) Irrig.		ns	ns	ns	ns	ns	1.6	ns	ns	ns	ns	ns
LSD (0.05) Var.		1.9	2.9	3.6	3.1	1.0	1.1	1.9	2.8	2.1	0.2	2.1
LSD (0.05) Irr X Var		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 4. Stem-end fry color and tuber specific gravity response of six potato cultivars to four irrigation treatments. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Irrigation criteria	Irrigation intensity	Fry color	Spec. gravity	Variety	Irrigation criteria	Irrigation intensity	Fry color	Spec. gravity
	kPa	% of Et replaced	% reflectance			kPa	% of Et replaced	% reflectance	
R. Burbank	-60	100	38.3	1.091	R. Russet	-60	100	42.3	1.097
	-80	100	39.1	1.089		-80	100	44.6	1.103
	-80	70	40.7	1.090		-80	70	46.1	1.101
	-80	50 until stolon hooking, then 70 for 6 weeks, then 50	42.3	1.091		-80	50 until stolon hooking, then 70 for six weeks, then 50	44.4	1.102
		Average	40.1	1.090			Average	44.4	1.100
Shepody	-60	100	44.9	1.085	AO 82611-7	-60	100	43.8	1.090
	-80	100	47.9	1.090		-80	100	44.8	1.095
	-80	70	47.1	1.089		-80	70	45.6	1.094
	-80	50 until stolon hooking, then 70 for 6 weeks, then 50	47.8	1.091		-80	50 until stolon hooking, then 70 for six weeks, then 50	46.3	1.094
		Average	46.9	1.088			Average	45.1	1.093
F. Russet	-60	100	36.5	1.090	COO 83008-1	-60	100	49.3	1.099
	-80	100	38.3	1.090		-80	100	51.1	1.100
	-80	70	40.7	1.091		-80	70	52.4	1.099
	-80	50 until stolon hooking, then 70 for 6 weeks, then 50	41.2	1.091		-80	50 until stolon hooking, then 70 for six weeks, then 50	48.2	1.090
		Average	39.2	1.091			Average	50.3	1.095
Six varieties	-60	100	42.5	1.092					
	-80	100	44.3	1.095					
	-80	70	45.4	1.094					
	-80	50 until stolon hooking, then 70 for 6 weeks, then 50	45.0	1.093					
LSD (0.05) Irrig treat			2.9	ns					
LSD (0.05) Variety			1.7	0.004					
LSD (0.05) Irr x var			ns	ns					

Table 5. Total available soil nitrogen at different depths before planting and after harvest of potatoes irrigated with slight water deficits. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Irrigation treatment	Available N (Nitrate N + ammonium N)													
	0-1 ft		1-2 ft		2-3 ft		3-4 ft		4-5 ft		5-6 ft		total	
	bfr	aftr	bfr	aftr	bfr	aftr	bfr	aftr	bfr	aftr	bfr	aftr	bfr	aftr
	---------- lbs/ac ----------													
1	31	61	24	41	31	37	26	38	18	40	48	44	178	261
2	31	69	24	35	31	34	26	35	18	40	48	35	178	248
3	31	61	24	36	31	36	26	39	18	34	48	36	178	242
4	40	71	26	40	35	36	28	43	25	42	56	52	210	284
Average	33	66	25	38	32	36	27	39	20	39	50	42	186	259

Table 6. Influence of irrigation treatment on nitrogen accounting in the soil profile (0-6 feet) between spring pre-plant and post-harvest soil sampling. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Irrigation treatment	Available nitrogen sources 0-6 feet				Fall nitrogen accounting 0-6 feet		
	Pre-plant soil nitrate and ammonium-N	Fertilizer N	N in irrigation water	Estimated N from organic matter mineralization less leaching losses*	Fall available N	Plant N recovery	Accounted N
1	178	110	22	207	261	256	517
2	178	110	14	207	248	259	507
3	178	110	14	175	241	234	475
4	210	110	14	185	285	234	519
LSD(0.05)					ns	ns	ns

* Based on the difference between N supplies and fall N accounting.

Figure 1. Russet Burbank petiole nitrate over time for potatoes irrigated at -60 kPa with 100 percent of potato Et$_c$ replaced. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

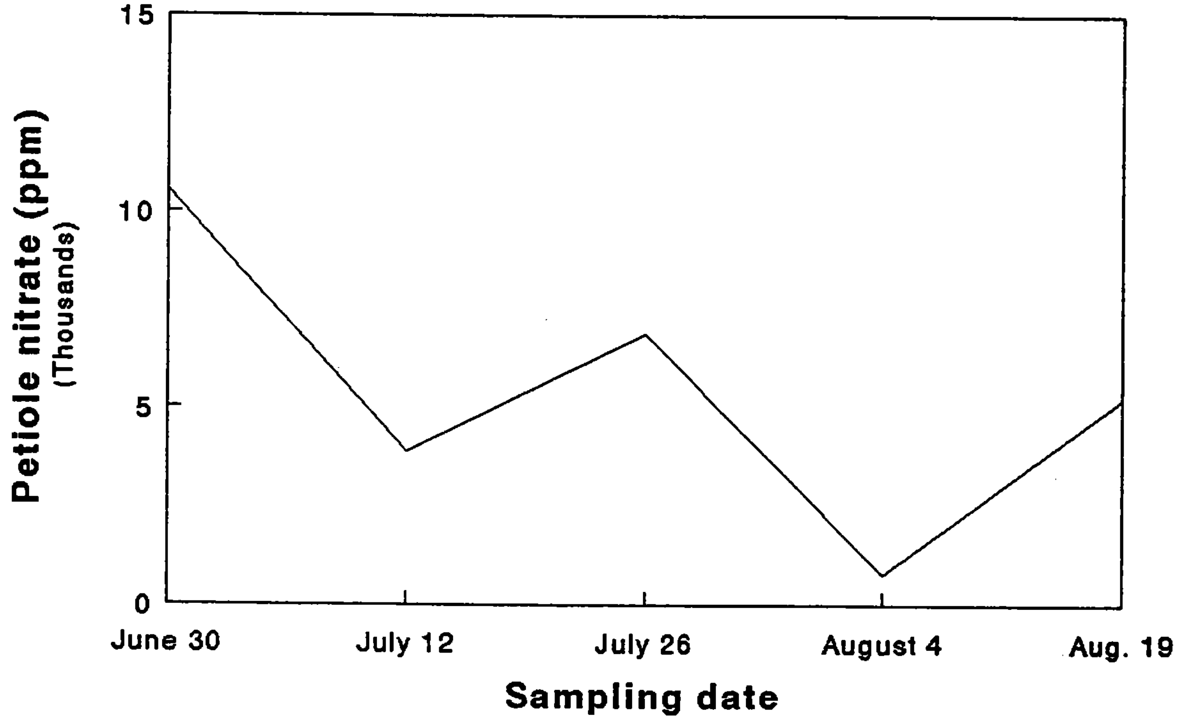


Figure 2. Comparison of cumulative potato ET$_c$ with cumulative irrigation water applied to four irrigation treatments during the 1992 season. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

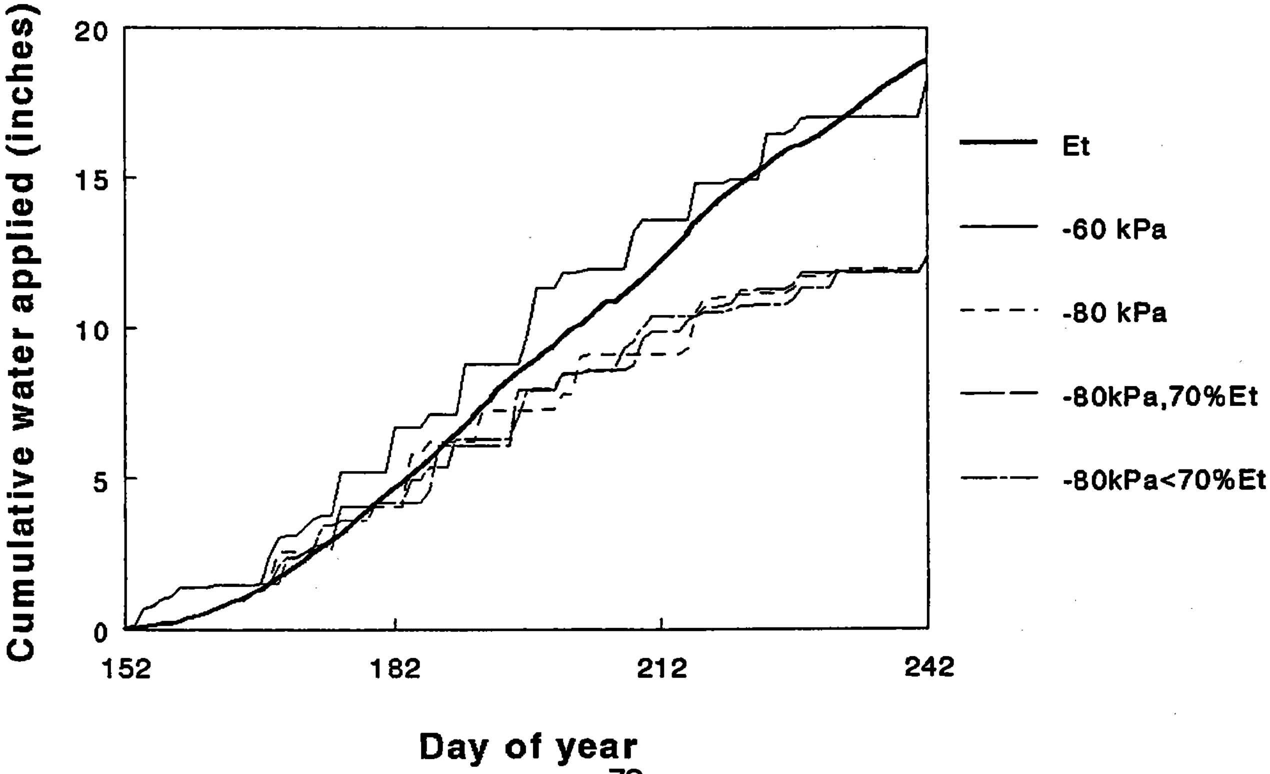


Figure 3. Soil water potential in the first and second foot of soil for irrigation treatment 1, replacing 100 percent of potato ET_c at -60 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

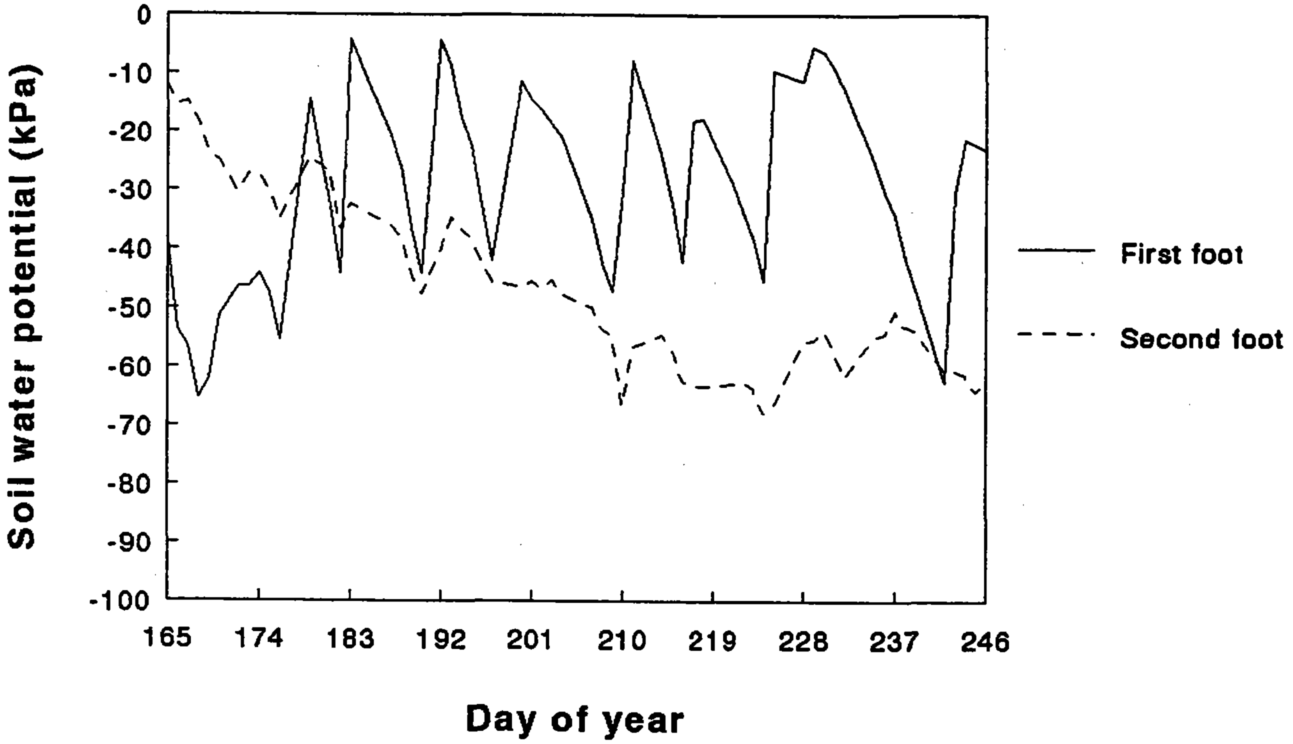


Figure 4. Soil water potential in the first and second foot of soil for irrigation treatment 2, replacing 100 percent of potato ET_c at -80 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

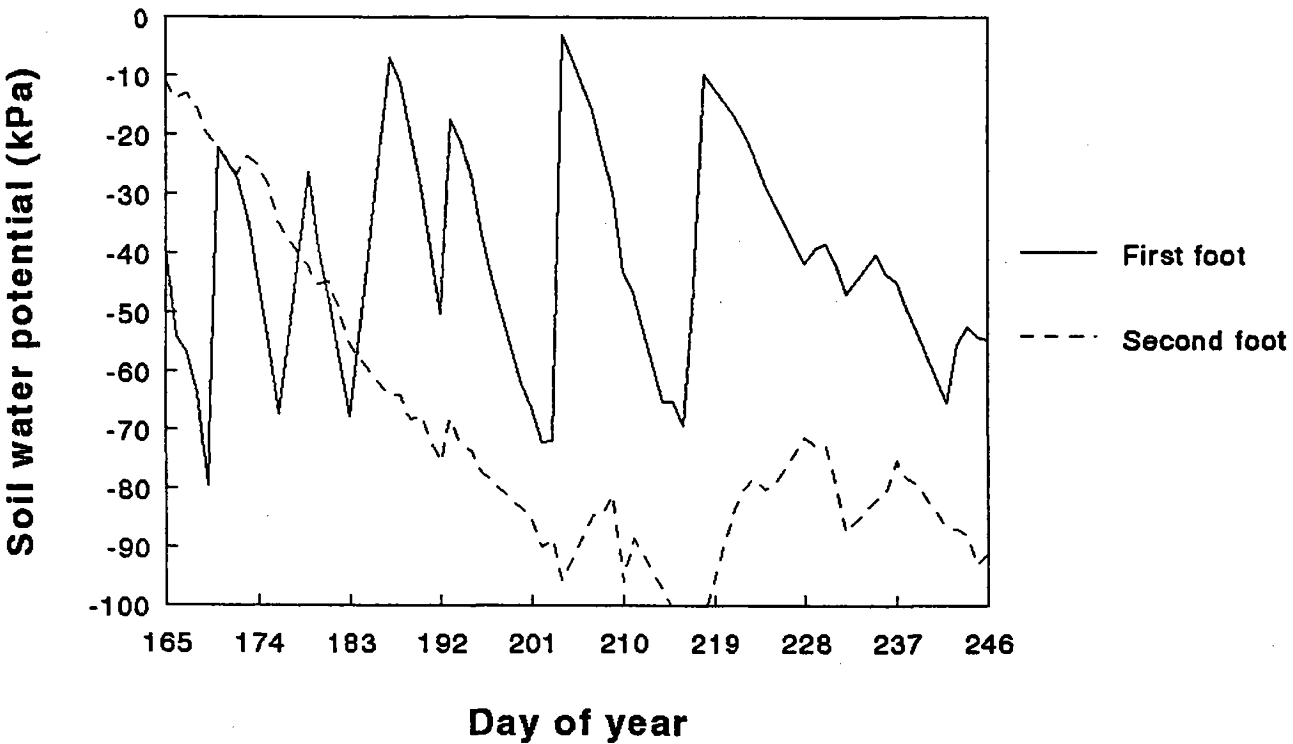


Figure 5. Soil water potential in the first and second foot of soil for irrigation treatment 3, replacing 70 percent of potato ET_c at -80 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

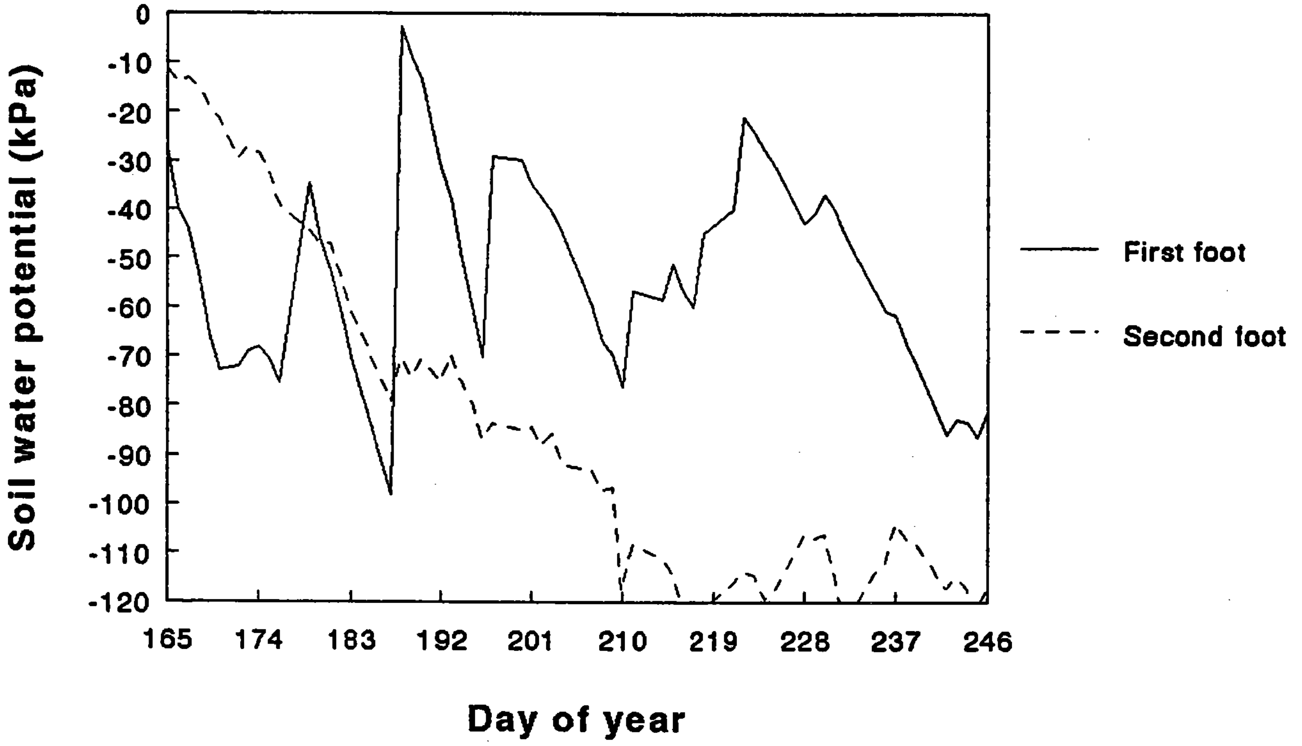


Figure 6. Soil water potential in the first and second foot of soil for irrigation treatment four, replacing 50 percent, 70 percent, then 50 percent of potato ET_c at -80 kPa. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

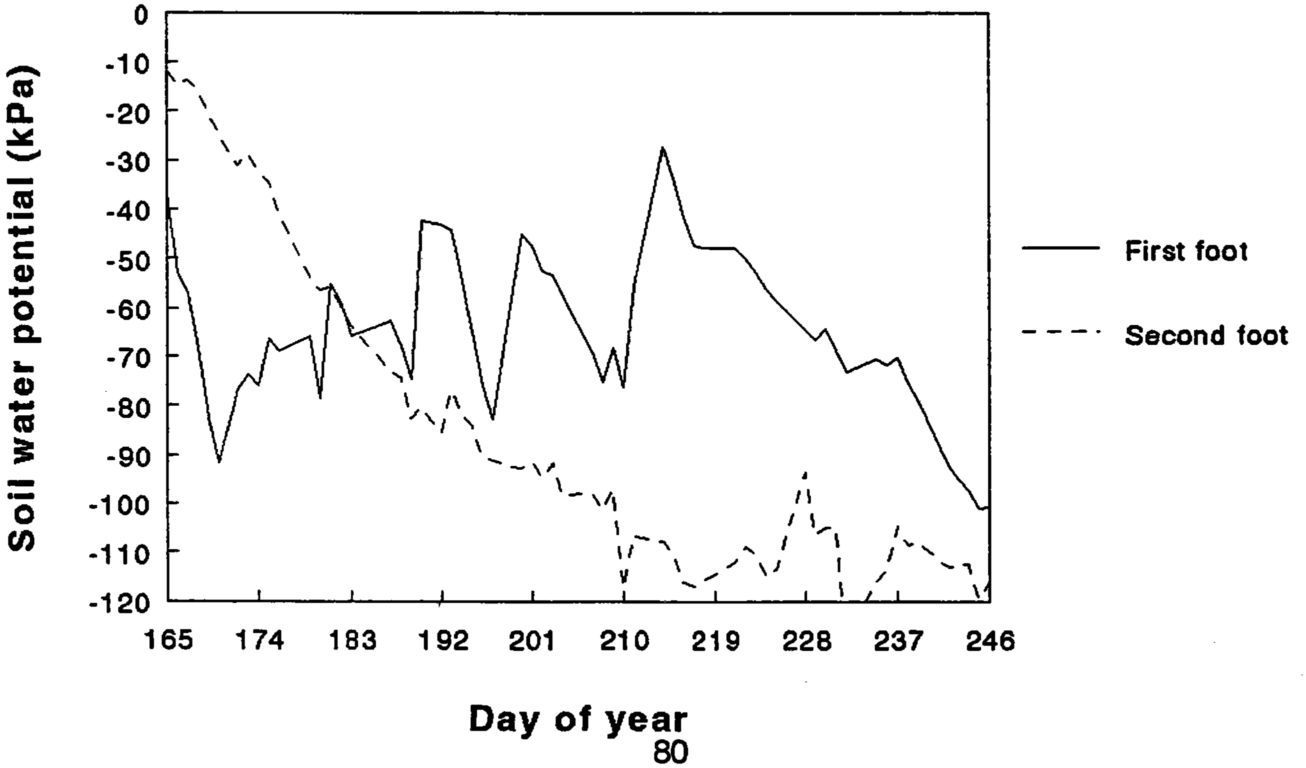


Figure 7. Influence of irrigation treatment on residual soil nitrate after harvest compared to pre-plant (spring) levels. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

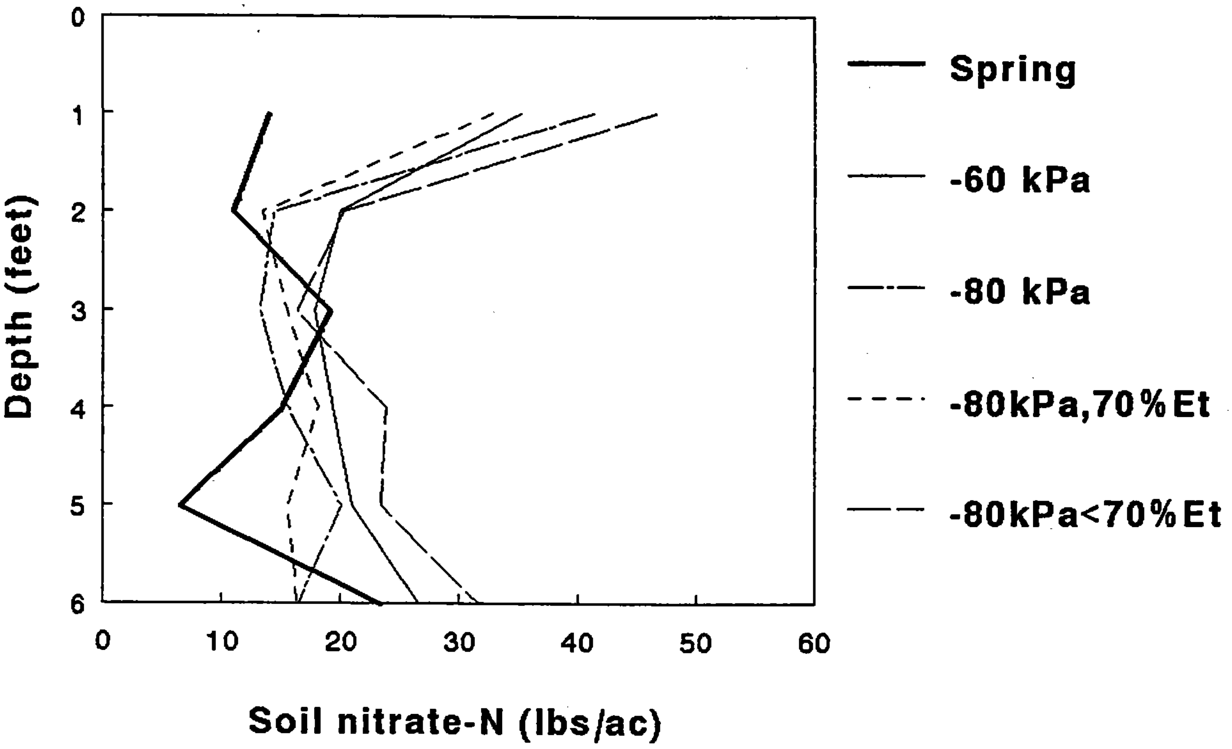
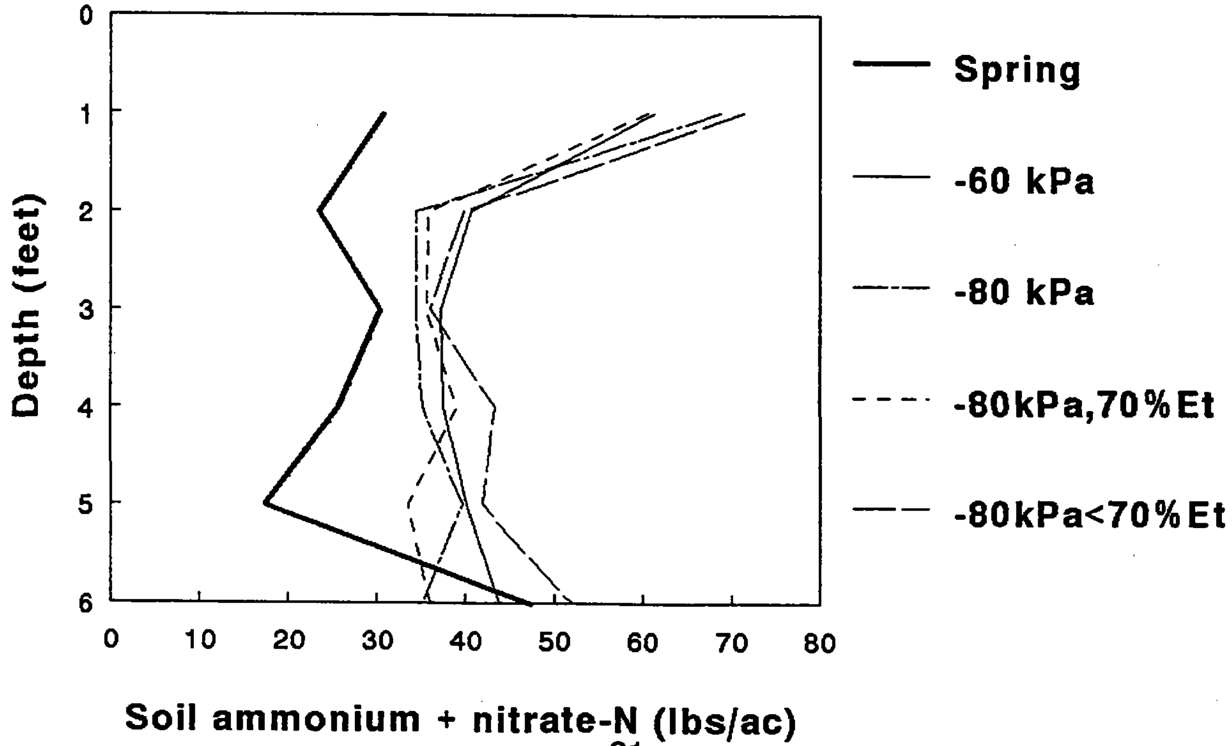


Figure 8. Influence of irrigation treatment on residual soil inorganic nitrogen (nitrate + ammonium) after harvest compared to pre-plant (spring) levels. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.



NITROGEN FERTILIZATION FOR POTATO VARIETIES GROWN IN THE TREASURE VALLEY, 1993 TRIAL

Erik Feibert, Clint Shock, and Monty Saunders
Malheur Experiment Station
Ontario, Oregon

Introduction

Potato producers in the Treasure Valley have new market opportunities to produce and sell Shepody, Frontier Russet, and Ranger Russet varieties to potato processors. Producers have occasionally experienced difficulty obtaining uniform high yields with these new varieties. Tuber specific gravity is also a problem for some producers. Producers suspect that yield and quality failures may be related to nitrogen and irrigation management.

Producers have been advised by processor representatives to use less nitrogen fertilizer and less water on Shepody than on Russet Burbank (2). Producers have also been advised to apply N on Shepody earlier in the season than on Russet Burbank (2). Fertilization recommendations for Shepody potatoes are based on research at Klamath Falls (1) and east maritime Canada. Doubts persist whether the recommendations are appropriate for the Treasure Valley of eastern Oregon and southwestern Idaho.

Potato growers typically apply in the range of 150 to 400 lbs of N per acre. Crop yields remove approximately 100 to 220 lbs N/ac. Residual fertilizer nitrogen not recovered by the potato crop is subject to conversion to nitrate, which is at risk of leaching to the groundwater. Oregon DEQ has voiced concerns over groundwater nitrate in principal potato production areas; Hermiston-Boardman, Klamath Falls, and Malheur County. Could new approaches to N fertilization assure yields to the grower with lower N inputs and lower costs?

This trial was the second year of examining whether Shepody, Frontier Russet, Ranger Russet and other promising varieties need less nitrogen fertilizer than Russet Burbank, and should only be fertilized early during the season for optimum yield and tuber quality. In addition to Russet Burbank, Shepody, Frontier Russet, and Ranger Russet, three of the most promising varieties in the statewide variety development program were also tested for their response to N fertilization.

Procedures

Twenty lbs of N/ac and 100 lbs of P_2O_5/ac as monoammonium phosphate plus 10 lbs of Z/ac as zinc sulphate were broadcast in the fall of 1992 on an Owyhee silt loam previously planted to spring wheat at the Malheur Experiment Station. A soil sample taken from the top foot on April 15, 1993, showed a pH of 7.3, 1.5 percent organic matter, 8 CEC, 8 ppm nitrate-N, 7 ppm ammonium-N, 26 ppm phosphorus, 569 ppm potassium, 2900 ppm calcium, 280 ppm magnesium, 257 ppm sodium, 7.1 ppm zinc, 7.2 ppm iron, 14.4 ppm manganese, 1.3 ppm copper, 7 ppm sulfur, and 0.6 ppm boron. The field was bedded into 36-inch hills in the spring of 1993. Prowl at 1 lb ai/ac and Dual at 2 lbs ai/ac were sprayed on May 6 and incorporated during planting. Two-ounce seed pieces were planted May 7 at 9-inch spacing. Thimet 20G was sidedressed at 3 lbs ai/ac with the urea treatments on May 14. Bravo 500 was applied at 0.6 pint ai/ac for preventive control of leaf fungi on June 25. Uniroyal ZKP (0-16-9, 1% Zn) was simultaneously applied at 2 qts/ac.

Nitrogen fertilizer treatment levels and timing are presented in Table 1. Pre-tuber set treatments of sidedressed urea were made on May 14. The experimental design had six N treatments as main plots and varieties as split-plots within the main plots (Table 1). Nitrogen treatments were replicated five times.

Table 1. Nitrogen fertilizer rates and timing. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment number	Nitrogen fertilizer supply	Nitrogen timing
1.	240 lbs N/ac	All before tuber set
2.	180 lbs N/ac	All before tuber set
3.	120 lbs N/ac	All before tuber set
4.	Only residual N soil supply	None
5.	180 lbs N/ac	Spread evenly over the season (5 split applications)
6.	180 lbs N/ac (3 split applications)	Applied until one month after tuber set

Treatments 1, 2, 3, and 4 constituted four nitrogen rates (Table 1). Treatments 2, 5, and 6 were three nitrogen application strategies.

The soil was sampled to 6 feet for nitrate and ammonium both before planting and after harvest. Nitrogen supply and residual fertilizer nitrogen were calculated. Irrigation water was assumed to contribute 1.35 lbs N/ac/inch. Petiole samples were collected every two weeks from potato plants of Russet Burbank, Shepody, and Frontier Russet varieties in each plot during tuber bulking to help interpret the effectiveness of the nitrogen treatments.

The crop was irrigated with a solid set sprinkler system with nozzles spaced 40 feet by 50 feet with an application rate of 0.12 inch/hr. Thirty granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS , Irrometer Co., Riverside, CA) were used to measure soil water potential. Fifteen GMS were centered 8 inches below the hill surface (top of GMS was 6 inches from soil surface) and offset 6 inches from the hill center, and fifteen GMS were centered 20 inches below the hill surface (18 inches from top of GMS to soil surface) and offset 6 inches from the hill center. GMS had been previously calibrated to soil water potential. Sensors were read five times per week from June 14 to September 3. The crop was irrigated when soil water potential in the first foot reached -60 kPa. Due to an unusually wet winter and spring, the soil water potential was -16 kPa in the second foot of soil and -38 kPa in the first foot of soil on June 14. This indicated a substantial amount of water in the profile that could be available to the plant by a combination of upward capillary movement and root absorption. This resulted in the GMS responding more slowly than expected from the potato evapotranspiration (ET_c) data from the AgriMet weather station. Consequently, in order to keep the top foot GMS below -60 kPa, less water than the accumulated ET_c was required. It was decided to limit water applications to 1.2 inches when GMS data indicated irrigations were necessary. As a result, only the first three irrigations had 100 percent of ET_c applied.

All tubers were harvested October 3 and evaluated for yield and grade. A representative 40 tuber subsample was stored for determination of tuber specific gravity and fry color in early November.

Results and Discussion

US Number One, marketable, and total tuber yields of the potato varieties were significantly increased by N fertilization in 1993 (Table 2). The check treatments resulted in a substantial reduction in US Number One, marketable, and total yields, and in percent US Number One >10 oz and percent marketable tubers for all varieties. There was no significant increase in US Number One, marketable, or total yields as a result of applying the fertilizer in split applications compared to a single application for any variety except for AO 82611-7, which responded to 180 lbs N/ac in five split applications with significantly higher US Number One and total yields than 180 lbs N/ac in a single application. A single application of 120 lbs N/ac at planting to Russet Burbank was among the most productive treatments in terms of US Number One tubers and marketable yield. A single application of 120 lbs N/ac at planting to Shepody potatoes was the most productive treatment in 1993 as it was in 1992. Frontier Russet did not show a significant response to the nitrogen rates. For COO 83008-1, a single application of 240 lbs N/ac or 180 lbs N/ac in 3 applications were among the most productive in terms of US Number One tubers. A single application of 180 lbs N/ac or 180 lbs N/ac split in three applications were among the most productive treatments in terms of US Number One tubers for NDTX 8-731-1R.

Tuber stem-end fry color was significantly affected by nitrogen fertilization, but the effect differed by variety (Table 4). Russet Burbank tubers from the check plots and from the plot receiving 240 lb N/ac rate applied as a single treatment had dark stem-end fry color. A single early N treatment resulted in lighter Frontier Russet stem-end tuber fry color than the unfertilized check. The check treatment resulted in significantly higher tuber specific gravity for all varieties.

The petiole nitrate levels of the check treatment of the three varieties tested dropped very quickly and were below the adequate range by June 30 (Figures 1-6) according to established guidelines (3). Petiole nitrate levels for all the other nitrogen fertilizer treatments remained at or above the adequate range during the season for all varieties. In the 1992 trial, petiole nitrate levels for the check treatment started at the deficient range, but dropped very little, and by mid- to late season the petiole nitrate levels were in the adequate range. The difference in the rate of decline of petiole nitrate levels between the 1992 and 1993 trials can be attributed to higher amounts of mineralized nitrogen in 1992 due to alfalfa being the previous crop, while in 1993 the previous crop was spring wheat.

Soil water potential in the first foot of soil remained above -60 kPa during the season except for a short period in June (Figure 7). The soil water potential in the second foot of soil was wetter than in the first foot at the beginning of the season. However, by early July the soil water potential in the second foot of soil was drier than in the first foot and remained so for the rest of the season, suggesting that water was extracted from the second foot of soil and that nitrate leaching was minimal. A total of 12.4 inches of irrigation water was applied in 10 irrigations. Rainfall totaled 2.23 inches. The total of 14.6 inches as irrigation and rainfall was less than potato crop evapotranspiration (ET_c), 19 ac-inches.

Increasing rates of nitrogen fertilizer resulted in increasing amounts of available soil nitrogen in the top foot of soil after harvest compared to the check (Figures 9-12). Available soil nitrogen levels after harvest were similar for the three nitrogen fertilizer timing treatments, and higher than the check. From 2-6 feet, the available soil nitrogen levels after harvest were similar for all treatments including the check. Large nitrogen accounting surpluses were found for all treatments (Table 5 and 6), suggesting a significant role for an undefined source of nitrogen at this site.

Conclusions

The results of this trial underline the importance of refining the measurement of nitrogen contributions from organic matter decomposition and the previous crop residues. Potato response to nitrogen fertilizer can depend on the previous crop. In 1992 with alfalfa seed as the previous crop, nitrogen fertilization had negative effects on tuber yield, grade, and quality for some varieties. In 1993 with spring wheat as the previous crop, nitrogen fertilization to 120 lbs N/acre had a positive effect in terms of tuber yield, grade, and quality for most varieties. The amounts of residual available soil nitrogen in the spring in 1992 and 1993 were similar.

Split applications of the nitrogen fertilizer had no beneficial effects compared to a single application, and for Frontier Russet (early maturing) had a negative effect on fry color.

These results also stress the importance of determining and taking into account other sources of nitrogen, as the large amounts of N estimated to have been contributed from organic matter indicate.

In addition the results also demonstrate the feasibility of achieving optimum tuber yields and quality with sprinkler irrigation without nitrate leaching through careful irrigation management. With control over the movement of nitrate through irrigation management, the responses of the crop to nitrogen fertilization can be better defined.

Acknowledgements

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Table 2. Yield response of seven potato cultivars to six nitrogen fertilizer treatments. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

		Potato yield by market grade											Total yield
		US Number One				US Number Two				Total marketable	Rot	Undersize	
Variety	Nitrogen treatment	4-6 oz	6-10 oz	>10 oz	total	4-6 oz	6-10 oz	>10 oz	total				
		cwt/ac											
R. Burbank	1	87.5	133.4	98.5	319.4	36.2	49.4	44.2	129.7	449.1	0.3	117.7	567.2
	2	97.3	122.1	87.5	306.8	27.6	41.3	39.3	108.3	415.1	0.2	134.9	550.2
	3	107.9	141.4	97.1	346.4	32.8	43.7	29.7	106.3	452.7	0.5	117.4	570.6
	4	129.9	84.6	13.8	228.2	28.1	24.9	8.2	61.2	289.4	2.2	133.9	425.5
	5	104.9	133.8	94.1	332.8	25.6	29.4	29.1	84.1	416.9	0.3	127.4	544.6
	6	92.1	131.4	110.6	334.1	37.8	43.1	30.2	111.1	445.2	0.9	128.1	574.2
	Average	103.3	124.5	83.60	311.3	31.4	33.7	30.1	100.1	411.4	0.7	126.6	538.7
Shepody	1	29.4	54.9	186.7	271.0	13.6	29.9	64.3	107.8	378.7	0.9	29.2	408.9
	2	28.3	57.2	197.8	283.3	12.8	24.9	52.3	90.1	373.3	0.0	28.6	401.9
	3	30.9	77.9	204.4	313.3	14.1	33.4	51.6	99.1	412.4	0.6	28.0	441.0
	4	28.5	66.0	103.6	198.2	11.0	19.3	26.6	56.9	255.1	0.4	35.3	290.8
	5	26.5	65.2	190.91	282.6	12.1	24.4	61.5	98.0	380.6	0.7	28.6	410.9
	6	34.2	52.7	177.8	264.7	12.6	28.8	62.0	103.4	368.1	1.0	32.1	401.2
	Average	29.6	62.3	176.9	268.9	12.7	26.8	43.4	92.6	361.4	0.6	30.3	392.5
F. Russet	1	65.7	84.0	106.5	256.2	12.2	14.4	15.3	41.9	298.1	2.5	77.8	378.5
	2	62.0	106.5	81.0	249.5	10.3	23.0	29.2	62.5	312.1	1.6	79.2	392.9
	3	66.1	90.9	85.6	242.6	13.7	19.3	31.0	64.1	306.6	1.2	76.6	384.4
	4	82.6	110.6	41.7	234.8	19.3	17.9	7.5	44.6	279.5	3.2	81.4	364.1
	5	69.1	92.8	97.6	259.5	11.8	18.2	22.1	52.2	311.7	1.7	80.5	393.8
	6	64.3	86.3	77.0	227.6	18.1	21.2	23.0	62.3	289.9	1.0	83.9	374.8
	Average	68.3	95.2	81.6	245.0	14.2	19.0	21.4	54.6	299.7	1.9	79.7	381.4
R. Russet	1	98.8	127.5	112.0	338.3	24.4	30.7	36.1	91.2	429.5	0.8	80.9	511.2
	2	88.9	140.0	112.9	341.7	25.9	38.9	23.2	88.0	429.7	0.5	86.2	516.4
	3	94.4	118.0	92.9	305.3	25.0	34.0	22.8	81.9	387.1	0.5	81.1	468.8
	4	97.5	102.4	30.1	230.0	16.5	25.8	8.5	50.7	280.7	0.0	96.7	377.4
	5	78.2	118.0	126.4	322.5	19.0	41.0	41.0	101.0	423.4	2.3	90.4	516.1
	6	78.7	119.0	107.2	304.6	23.3	37.8	33.5	94.6	399.2	0.2	86.3	485.7
	Average	89.4	120.8	96.9	307.1	22.4	34.7	27.5	84.6	331.7	0.7	86.9	479.3
AO 82611-7	1	47.6	91.3	172.3	311.2	13.5	32.9	38.1	84.6	395.8	1.0	37.8	434.6
	2	47.6	105.8	127.8	281.2	21.6	58.9	46.2	126.8	408.0	0.0	43.0	451.0
	3	64.9	90.2	145.9	300.9	14.2	23.6	39.2	77.0	377.9	0.0	51.0	428.9
	4	80.4	115.6	56.9	252.8	16.9	26.7	16.9	60.6	313.4	0.9	65.1	379.4
	5	67.6	122.0	174.9	364.6	23.9	35.4	74.5	133.8	498.3	2.0	57.3	557.6
	6	45.8	101.7	169.1	316.6	17.1	27.7	60.5	105.3	421.9	0.0	45.9	467.8
	Average	59.0	104.4	141.2	304.6	17.9	34.2	45.9	98.0	402.6	0.7	50.0	453.2
COO 83008-1	1	27.3	68.8	277.5	373.7	10.6	31.3	81.4	123.2	496.9	0.0	23.0	519.9
	2	32.5	74.4	220.2	327.0	8.6	42.8	129.5	180.9	507.9	0.0	21.0	528.9
	3	25.1	68.8	243.1	337.0	16.1	30.6	79.2	125.9	462.9	0.0	25.4	488.3
	4	26.3	86.4	155.7	268.4	26.3	23.3	41.4	91.0	359.5	0.0	21.7	381.2
	5	18.9	67.8	257.5	344.1	11.5	30.6	98.3	140.3	484.4	0.4	17.4	502.2
	6	34.6	89.7	252.2	376.6	13.6	34.7	82.4	130.8	507.3	0.6	33.8	541.8
	Average	27.5	76.0	234.4	337.8	14.5	32.2	85.4	132.0	469.8	0.2	23.7	493.7
NDTX 8-731-1R	1	40.6	112.7	287.8	441.1	3.6	9.6	36.8	50.0	491.1	0.0	43.1	534.1
	2	44.5	124.0	319.7	488.3	2.7	6.9	29.4	39.0	527.2	0.8	29.4	557.5
	3	40.5	104.0	277.1	421.7	3.4	7.9	73.2	84.5	506.2	0.0	29.1	535.3
	4	56.2	128.6	157.7	342.5	1.2	6.0	8.0	15.2	357.7	0.0	32.0	389.6
	5	54.2	104.9	314.0	473.2	3.5	4.7	38.5	46.7	519.9	0.2	28.3	548.3
	6	50.1	132.1	328.9	511.0	3.2	13.5	14.4	31.1	542.2	0.0	30.2	572.4
	Average	47.7	117.7	280.9	446.3	2.9	8.1	33.4	44.4	490.7	0.2	32.0	522.9
All varieties	1	56.7	96.1	177.3	330.1	16.3	28.3	45.2	89.8	362.1	0.8	58.5	479.2
	2	57.3	104.3	163.8	325.4	15.6	33.8	49.9	99.4	424.8	0.4	60.3	485.5
	3	61.4	98.7	163.7	323.9	17.0	27.5	46.7	91.3	415.1	0.4	58.4	473.9
	4	71.6	99.2	79.9	250.7	17.0	20.6	16.7	54.3	305.0	1.0	66.6	372.6
	5	59.9	100.6	179.3	339.9	15.3	26.2	52.1	93.7	433.6	1.1	61.4	496.2
	6	57.1	101.8	174.7	333.6	18.0	29.5	43.7	91.2	424.8	0.5	62.9	488.3
LSD (0.05) N		6.6	ns	19.3	23.7	ns	5.5	10.3	11.5	24.7	ns	ns	22.1
LSD (0.05) Var.		6.0	12.3	16.8	19.8	3.6	4.6	7.6	5.6	22.9	0.8	6.7	22.6
LSD (0.05) N X V		14.8	30.1	ns	48.4	ns	11.4	18.7	13.7	ns	ns	ns	55.2

Table 3. Tuber market grade response of seven potato cultivars to six nitrogen fertilizer treatments. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

		Potato yield by market grade										
		US Number One				US Number Two						
Variety	Nitrogen treatment	4-6 oz	6-10 oz	>10 oz	total	4-6 oz	6-10 oz	>10 oz	total	Total marketable	Rot	Undersize
		%										
R. Burbank	1	15.3	23.6	17.2	56.1	6.4	8.5	7.7	22.7	78.8	0.1	21.1
	2	17.7	22.0	16.1	55.8	5.0	7.4	7.1	19.5	75.2	0.0	24.7
	3	19.0	24.8	16.8	60.5	5.6	7.6	5.1	18.3	78.9	0.1	21.0
	4	31.0	19.7	3.2	53.5	6.6	5.8	1.8	14.2	67.7	0.5	31.8
	5	19.3	24.4	16.9	60.6	4.8	5.4	5.3	15.5	76.1	5.7	23.8
	6	16.0	22.8	19.1	58.0	6.6	7.5	5.3	19.4	77.4	0.2	22.5
	Average	19.7	22.9	14.9	57.4	5.8	7.0	5.4	18.3	75.7	1.1	24.2
Shepody	1	7.2	13.6	45.4	66.2	3.4	7.3	15.7	26.4	92.6	0.2	7.2
	2	7.1	14.3	48.9	70.3	3.2	6.3	13.0	22.4	92.8	0.0	7.2
	3	7.1	17.7	46.2	80.0	3.2	7.5	11.7	22.4	93.4	0.1	6.4
	4	10.4	22.9	35.0	68.3	3.8	6.5	8.6	18.9	87.2	0.2	12.6
	5	6.5	15.6	46.5	68.7	2.9	5.9	15.2	23.9	92.6	0.4	7.1
	6	8.5	13.2	44.2	65.9	3.1	7.2	15.5	25.8	91.7	0.2	8.1
	Average	7.8	16.2	44.4	69.9	3.3	6.8	13.3	23.3	91.7	0.2	8.1
F. Russet	1	17.4	22.1	28.0	67.6	3.2	3.8	4.0	11.0	78.6	0.7	20.8
	2	15.8	26.6	20.8	63.2	2.7	5.9	7.4	16.0	79.2	0.4	20.4
	3	17.3	23.7	22.2	63.2	3.6	5.0	8.0	16.6	79.8	0.3	20.0
	4	22.5	30.6	11.3	64.4	5.3	4.9	2.1	12.3	76.7	1.0	22.3
	5	17.4	23.4	25.0	65.8	3.0	4.6	5.7	13.3	79.1	0.4	20.5
	6	17.2	23.1	20.4	60.7	4.7	5.7	6.1	16.4	77.2	0.3	22.6
	Average	17.9	24.9	21.3	64.2	3.8	5.0	5.6	14.3	78.4	0.5	21.1
R. Russet	1	19.3	24.8	21.9	66.0	4.8	6.0	7.1	17.9	83.9	0.2	16.0
	2	17.3	27.1	21.7	66.1	5.0	7.5	4.4	16.9	83.1	0.1	16.8
	3	20.2	25.1	19.8	65.2	5.3	7.2	4.8	17.3	82.5	0.1	17.4
	4	25.9	27.2	7.8	60.9	4.3	6.8	2.1	13.2	74.1	0.0	25.9
	5	15.1	22.8	24.3	62.2	3.7	7.9	8.0	19.6	81.9	0.5	17.7
	6	16.3	24.4	22.1	62.8	4.8	7.7	6.9	19.4	82.2	0.0	17.8
	Average	19.0	25.2	19.6	63.9	4.7	7.2	5.6	17.4	81.3	0.2	18.6
AO 82611-7	1	11.1	20.9	39.4	71.3	3.2	7.5	9.0	19.7	91.0	0.2	8.7
	2	10.6	23.5	28.3	62.4	4.8	13.1	10.3	28.1	90.5	0.0	9.5
	3	15.2	21.0	33.9	70.1	3.3	5.5	9.1	18.0	88.1	0.0	11.9
	4	21.2	30.5	14.9	66.6	4.4	7.1	4.5	16.0	82.6	0.2	17.2
	5	12.3	21.2	30.7	64.3	4.5	6.7	13.9	25.1	89.4	0.3	10.3
	6	9.8	21.9	36.1	67.7	3.6	5.9	12.9	22.4	90.2	0.0	9.8
	Average	13.4	23.2	30.6	67.1	4.0	7.6	10.0	21.6	88.6	0.1	11.2
COO 83008-1	1	5.3	13.2	53.4	71.9	2.0	6.0	15.6	23.6	95.5	0.0	4.5
	2	6.1	14.4	41.4	61.9	1.6	8.1	24.4	34.1	96.0	0.0	4.0
	3	5.1	14.1	49.8	69.0	3.3	6.3	16.2	25.8	94.8	0.0	5.2
	4	6.7	22.7	41.2	70.5	6.9	6.1	10.8	23.8	94.3	0.0	5.7
	5	3.7	13.5	51.3	68.6	2.3	6.1	19.5	27.9	96.5	0.1	3.5
	6	6.2	16.5	47.0	69.7	2.5	6.4	15.4	24.2	93.9	0.1	6.0
	Average	5.5	15.7	47.4	68.6	3.1	6.5	17.0	27.0	95.2	0.0	4.8
NDTX 8-731-1R	1	7.7	21.3	53.8	82.8	0.7	1.8	6.7	9.2	92.0	0.0	8.0
	2	8.0	22.3	57.2	87.5	0.5	1.2	5.3	7.1	94.6	0.1	5.3
	3	7.6	19.7	51.7	79.0	0.7	1.5	13.5	15.7	94.7	0.0	5.3
	4	14.4	33.0	40.4	87.8	0.3	1.5	2.1	3.9	91.7	0.0	8.3
	5	10.0	19.1	57.2	86.3	0.7	0.8	6.9	8.4	94.8	0.0	5.2
	6	8.8	23.2	57.0	89.1	0.5	2.5	2.6	5.6	94.7	0.0	5.3
	Average	9.4	23.1	52.9	85.4	0.6	1.6	6.2	8.3	93.8	0.0	6.2
All varieties	1	11.9	19.9	37.0	68.8	3.4	5.8	9.4	18.6	87.5	0.2	12.3
	2	11.80	21.46	33.49	66.74	3.26	7.07	10.27	20.59	87.34	0.09	12.56
	3	13.07	20.87	34.34	69.57	3.57	5.80	9.77	19.16	87.46	0.09	12.46
	4	18.87	26.66	21.97	67.43	4.51	5.53	4.57	14.61	82.04	0.27	17.69
	5	12.04	20.00	35.99	68.07	3.13	5.34	10.64	19.10	87.20	1.06	12.59
	6	11.8	20.7	35.1	67.7	3.7	6.1	9.2	19.0	86.8	0.1	13.2
LSD (0.05) N		1.5	2.2	3.6	ns	0.7	ns	2.3	2.4	1.7	ns	1.8
LSD (0.05) Var.		1.3	1.5	2.8	2.4	0.8	0.9	1.6	0.2	1.8	0.2	1.8
LSD (0.05) N X V		3.3	3.6	ns	5.9	ns	ns	4.0	0.4	ns	ns	ns

Table 4. Tuber stem-end fry color and specific gravity response of six potato cultivars to six nitrogen fertilizer treatments. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Nitrogen treatment rate and timing	Stem-end fry color	Specific gravity	Variety	Nitrogen treatment rate and timing	Stem-end fry color	Specific gravity
	lbs N/ac	% reflectance			lbs N/ac	% reflectance	
R. Burbank	240, all before tuber set	35.7	1.081	R. Russet	240, all before tuber set	44.8	1.095
	180, all before tuber set	41.0	1.084		180, all before tuber set	43.4	1.094
	120, all before tuber set	39.0	1.085		120, all before tuber set	44.3	1.093
	Residual soil N only	36.5	1.093		Residual soil N only	44.2	1.101
	180, divided evenly over season	39.1	1.085		180, divided evenly over the season	44.4	1.095
	180, divided evenly until one month after tuber set	38.3	1.083		180, divided evenly until one month after tuber set	44.8	1.095
	Average	38.3	1.085		Average	44.3	1.095
Shepody	240, all before tuber set	48.5	1.081	AO 82611-7	240, all before tuber set	45.4	1.088
	180, all before tuber set	47.1	1.080		180, all before tuber set	44.4	1.087
	120, all before tuber set	48.3	1.083		120, all before tuber set	46.2	1.090
	Residual soil N only	47.6	1.092		Residual soil N only	44.2	1.094
	180, divided evenly over season	50.6	1.080		180, divided evenly over the season	45.9	1.089
	180, divided evenly until one month after tuber set	46.8	1.079		180, divided evenly until one month after tuber set	44.3	1.088
	Average	48.2	1.082		Average	45.1	1.088
F. Russet	240, all before tuber set	40.0	1.084	COO 83008-1	240, all before tuber set	50.8	1.094
	180, all before tuber set	40.4	1.085		180, all before tuber set	50.3	1.092
	120, all before tuber set	38.7	1.087		120, all before tuber set	62.8	1.091
	Residual soil N only	35.5	1.099		Residual soil N only	47.2	1.102
	180, divided evenly over the season	35.1	1.084		180, divided evenly over the season	50.7	1.096
	180, divided evenly until one month after tuber set	35.7	1.084		180, divided evenly until one month after tuber set	47.5	1.093
	Average	37.6	1.087		Average	51.6	1.093
Six varieties	240, all before tuber set	44.2	1.087				
	180, all before tuber set	44.4	1.087				
	120, all before tuber set	46.6	1.087				
	Residual soil N only	42.5	1.097				
	180, divided evenly over the season	44.3	1.088				
	180, divided evenly until one month after tuber set	42.9	1.087				
LSD (0.05) N Trt		1.7	0.003				
LSD (0.05) Variety		1.5	0.001				
LSD (0.05) N X Var		3.7	ns				

Table 5. Influence of six nitrogen fertilizer treatments on nitrogen accounting in the soil profile (0-6 feet) between spring pre-plant and post-harvest soil sampling. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Nitrogen treatment	Nitrogen sources (0-6 feet)				Fall nitrogen accounting 0-6 feet		
	Spring		N in irrigation water	Estimated N from organic matter mineralization less nitrate leaching losses*			
	Available soil N	Fertilizer N			Fall available N	Plant N recovery	Accounted N
	---------------------------------- lbs/ac ----------------------------------						
1	219	240	17	283	494	265	759
2	219	180	17	254	428	242	670
3	219	120	17	222	337	241	578
4	219	0	17	242	322	156	478
5	219	180	17	251	417	250	667
6	219	180	17	279	397	298	695
LSD(0.05)					ns	33	158

* Based on the difference between N supplies and fall N accounting.

Table 6. Influence of six nitrogen fertilizer treatments on nitrogen accounting in the surface soil (0-2 feet) between spring pre-plant and post-harvest soil sampling. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Nitrogen treatment	Nitrogen supply 0-2 feet				Fall nitrogen accounting 0-2 feet		
	Spring		N in irrigation water	Estimated N from organic matter mineralization less nitrate leaching losses*			
	Available soil N	Fertilizer N			Fall available N	Plant N recovery	Accounted N
	---------------------------------- lbs/ac ----------------------------------						
1	70	240	17	203	265	265	530
2	70	180	17	164	189	242	431
3	70	120	17	169	135	241	376
4	70	0	17	175	106	156	262
5	70	180	17	163	180	250	430
6	70	180	17	192	161	298	459
LSD(0.05)					70	33	80

* Based on the difference between N supplies and fall N accounting.

Figure 1. Influence of early sidedress nitrogen fertilizer rates on Russet Burbank petiole nitrate. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

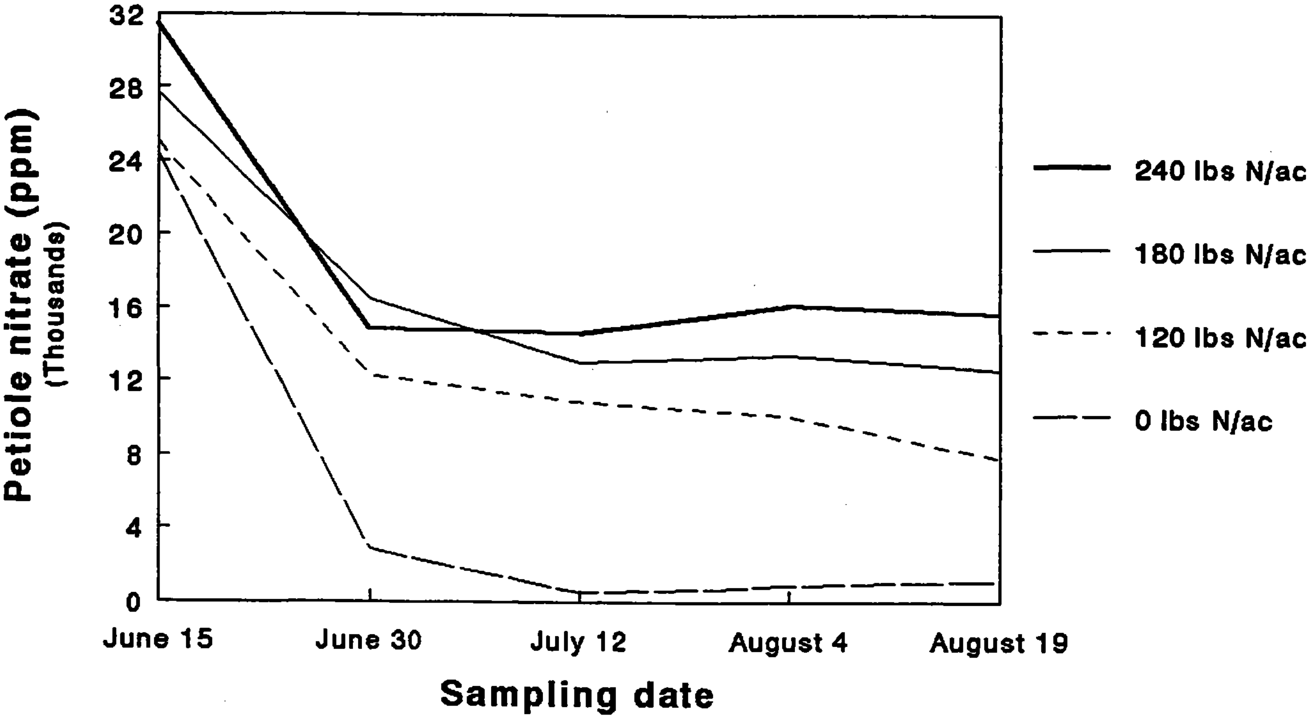


Figure 2. Influence of nitrogen fertilizer timing on Russet Burbank petiole nitrate. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

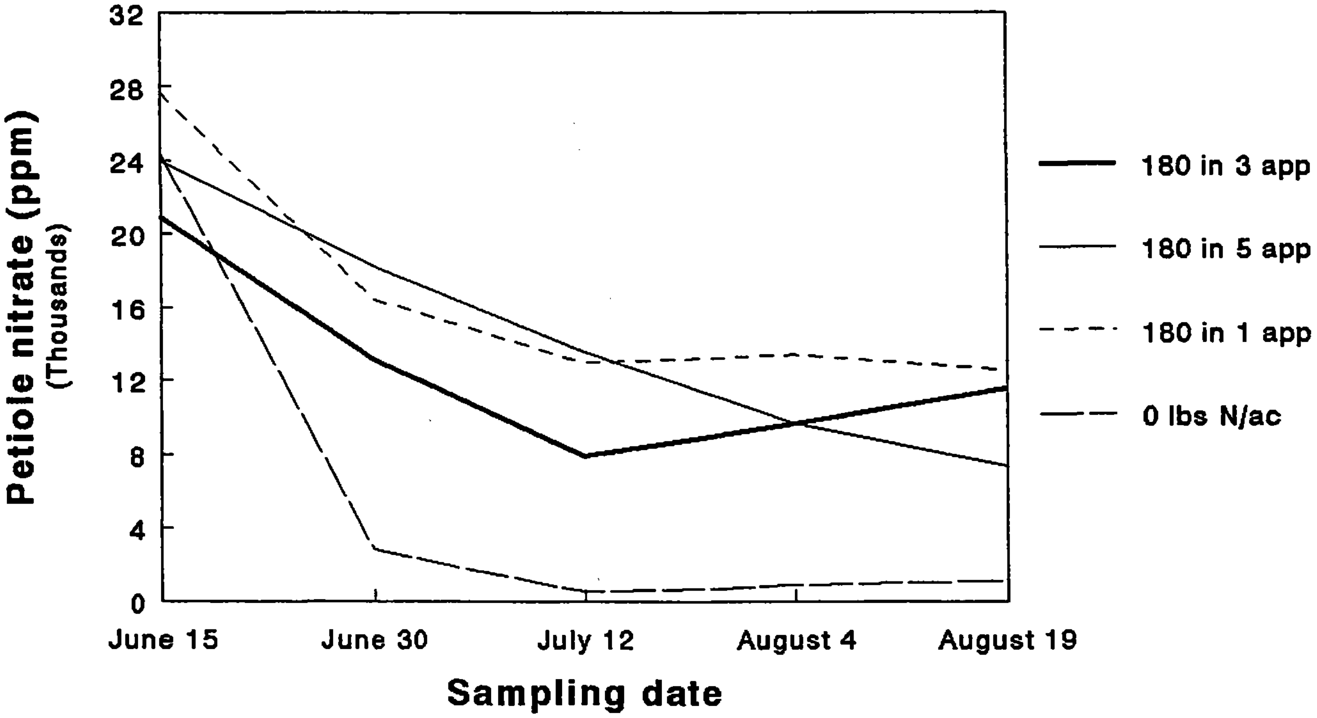


Figure 3. Influence of early sidedress nitrogen fertilizer rates on Shepody petiole nitrate. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

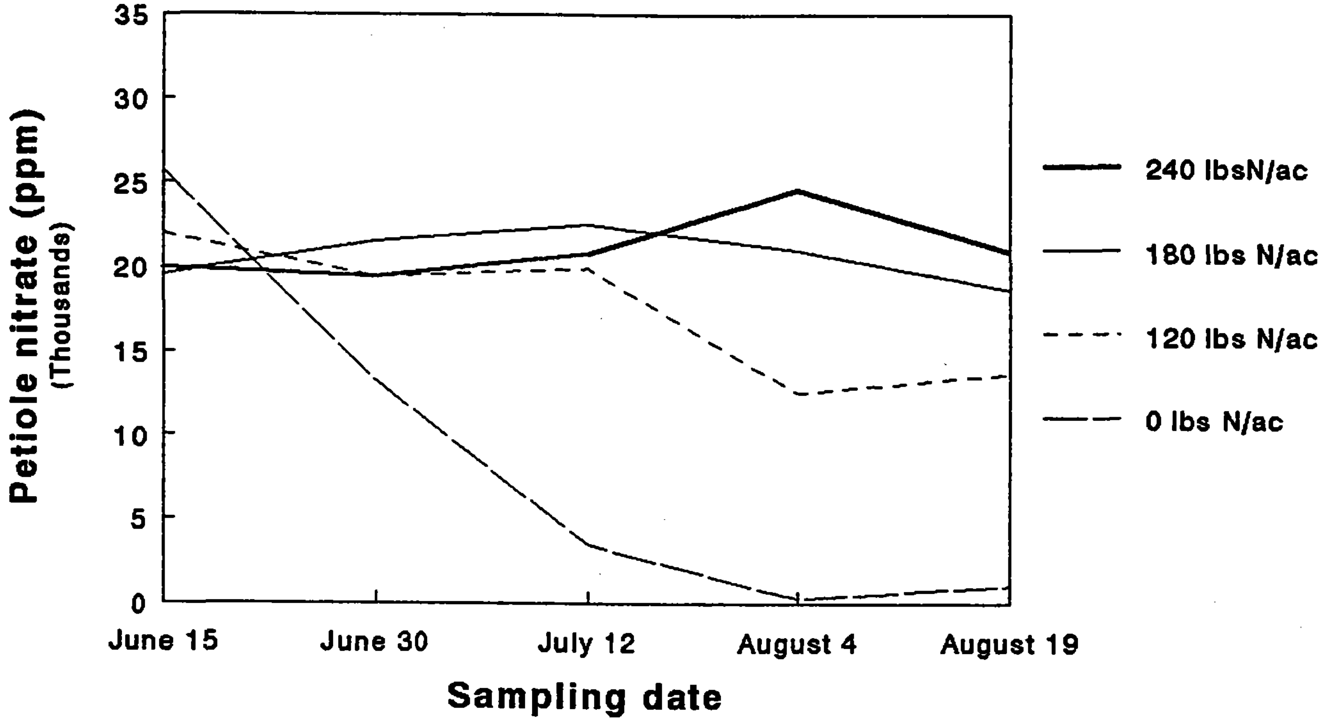


Figure 4. Influence of nitrogen fertilizer timing on Shepody petiole nitrate. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

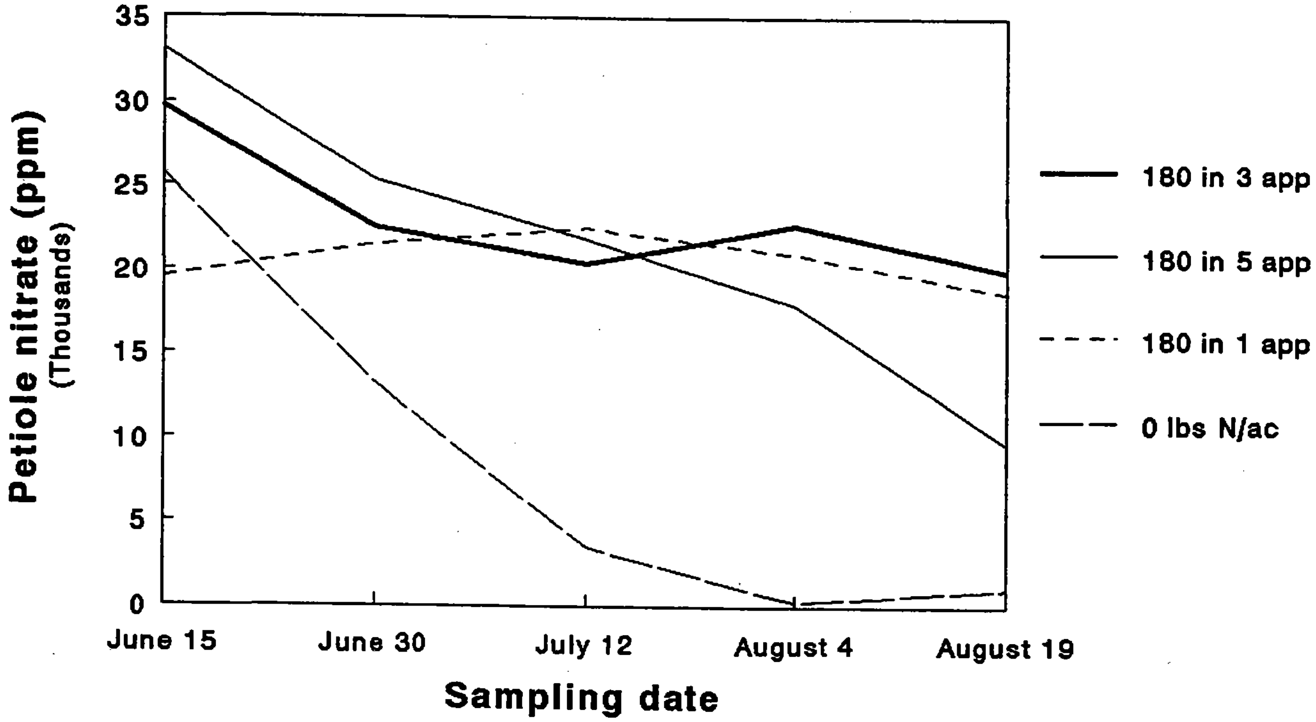


Figure 5. Influence of early sidedress nitrogen fertilizer rates on Frontier Russet petiole nitrate. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

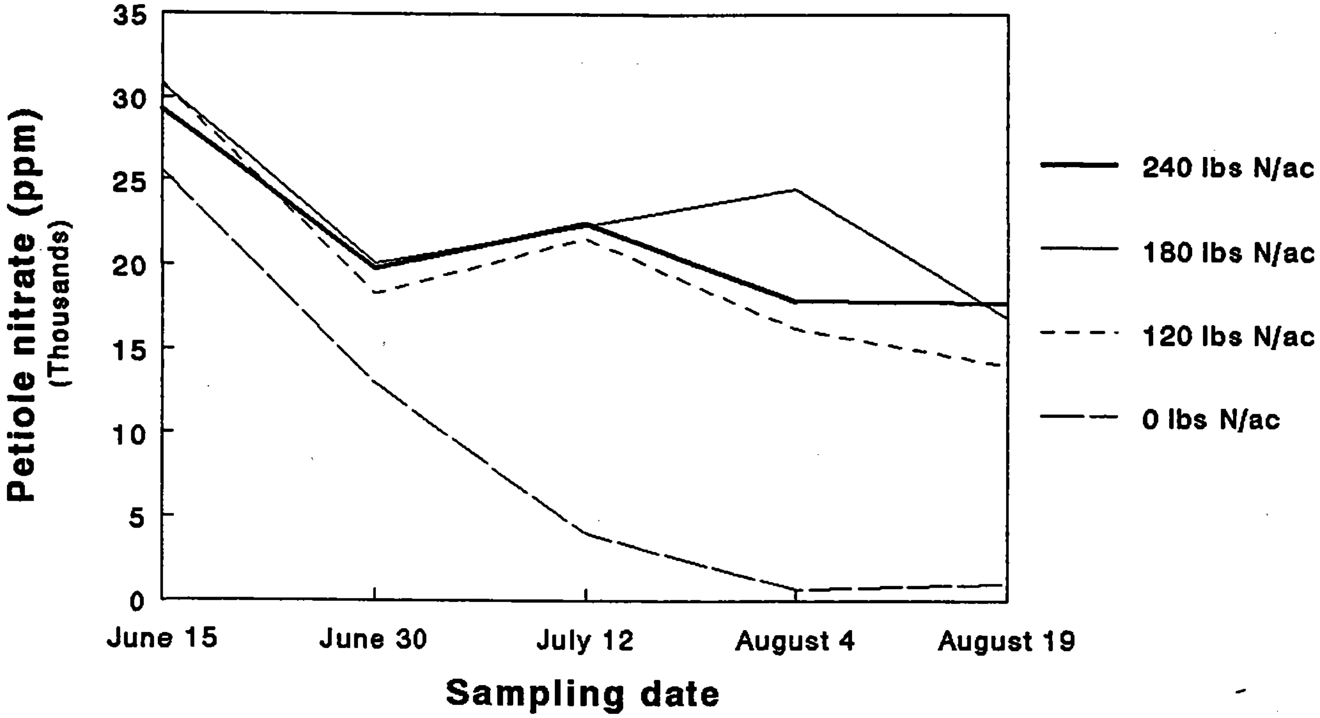


Figure 6. Influence of nitrogen fertilizer timing on Frontier Russet petiole nitrate. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

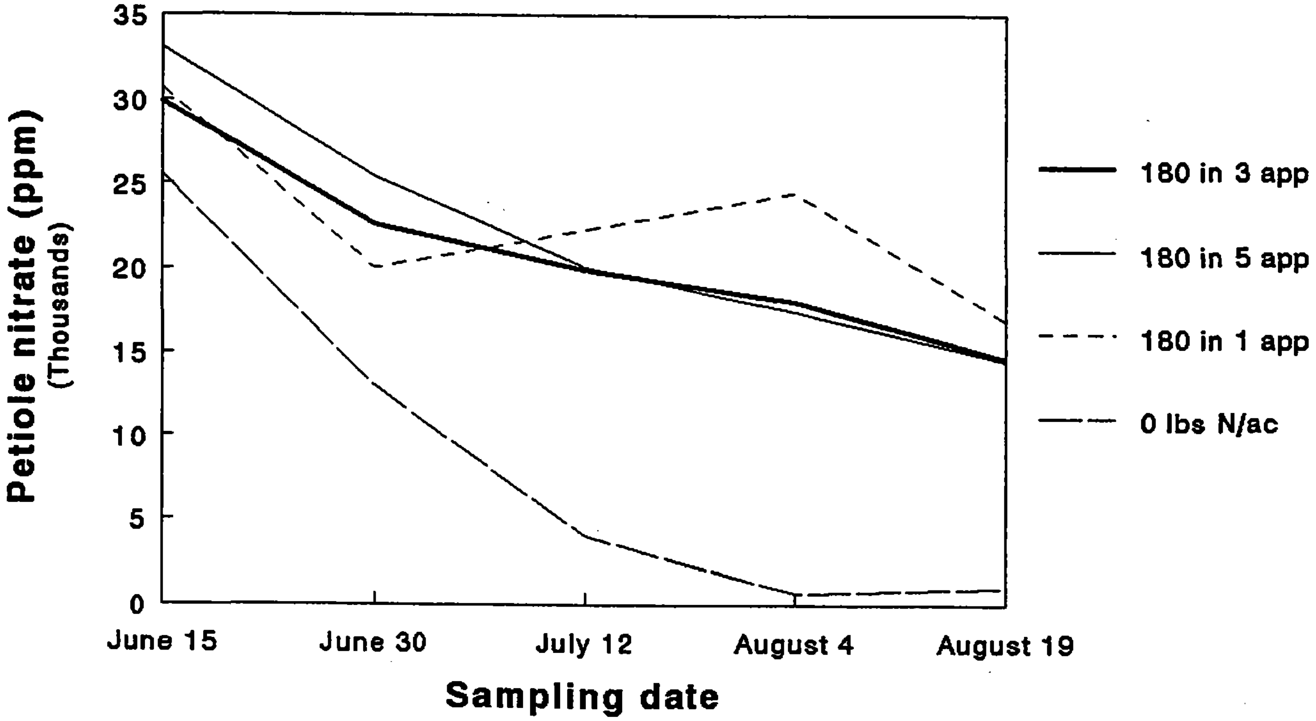


Figure 7. Soil water potential in the first and second foot of soil. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

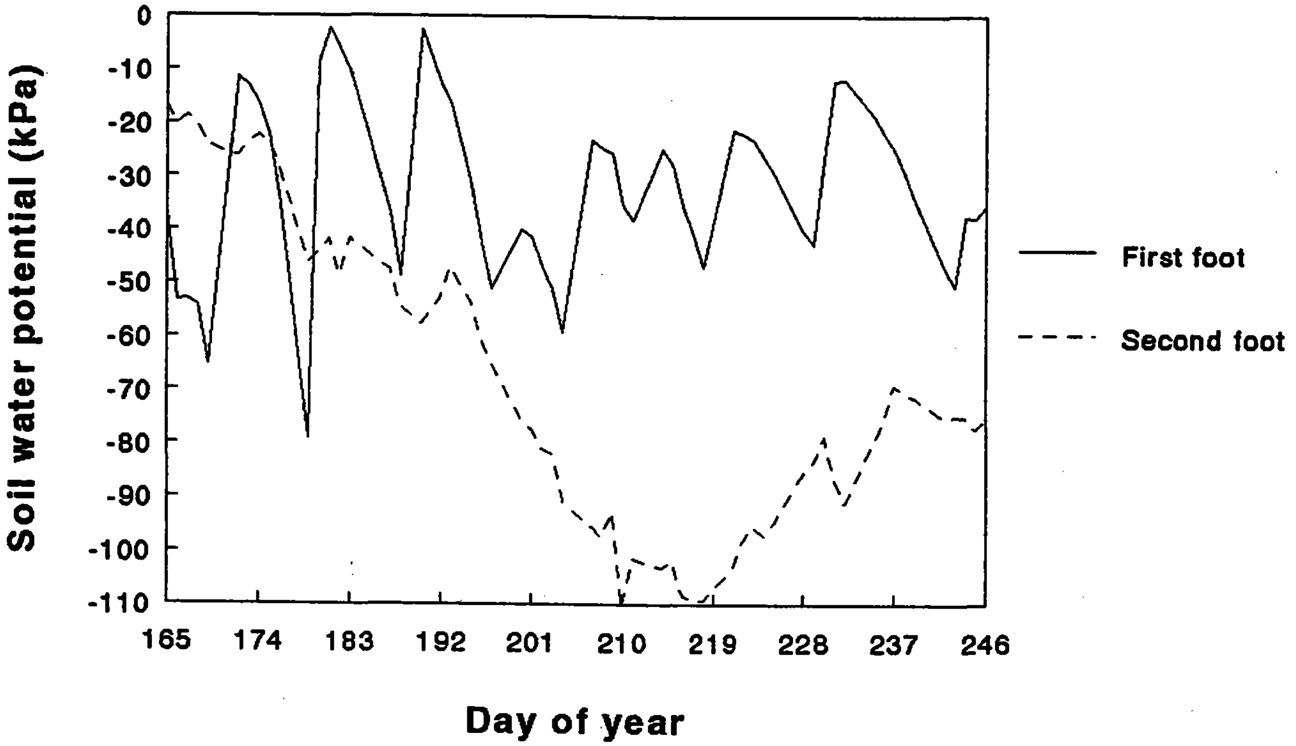


Figure 8. Cumulative water applied and potato evapotranspiration. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

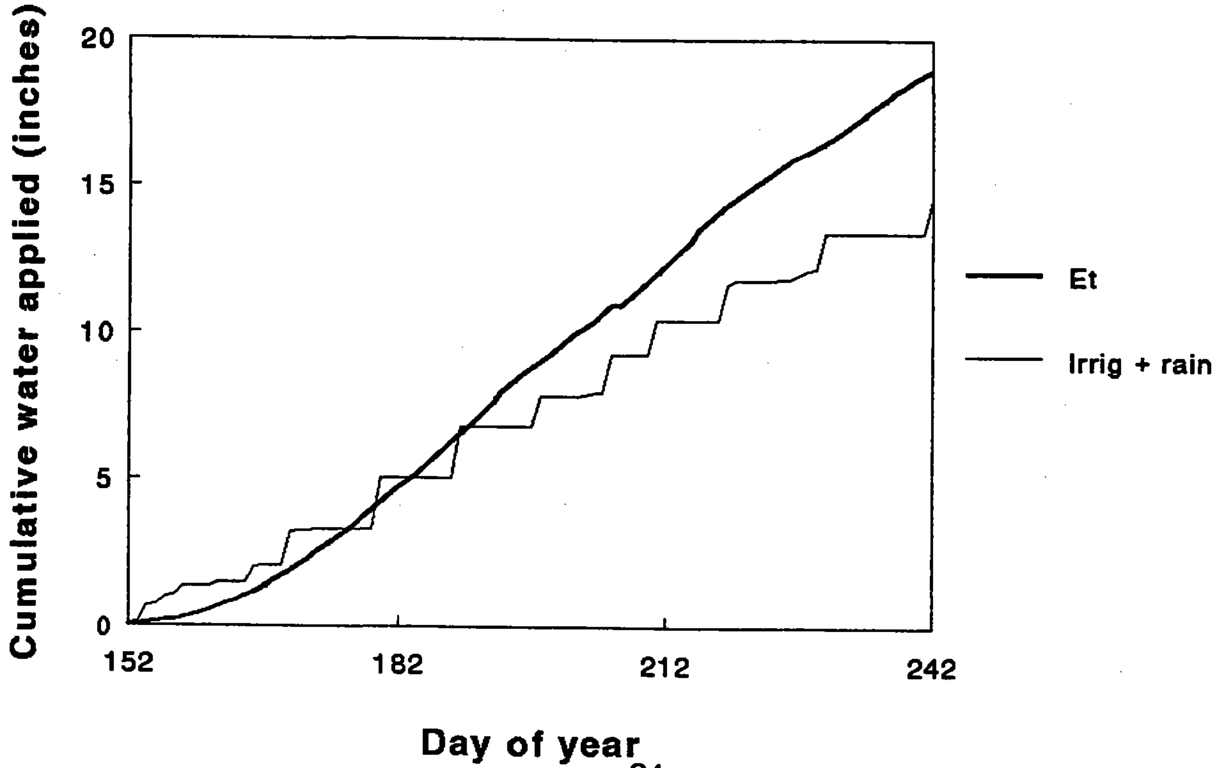


Figure 9. Influence of nitrogen fertilizer rate on residual soil nitrate after harvest compared to pre-plant (spring) levels. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

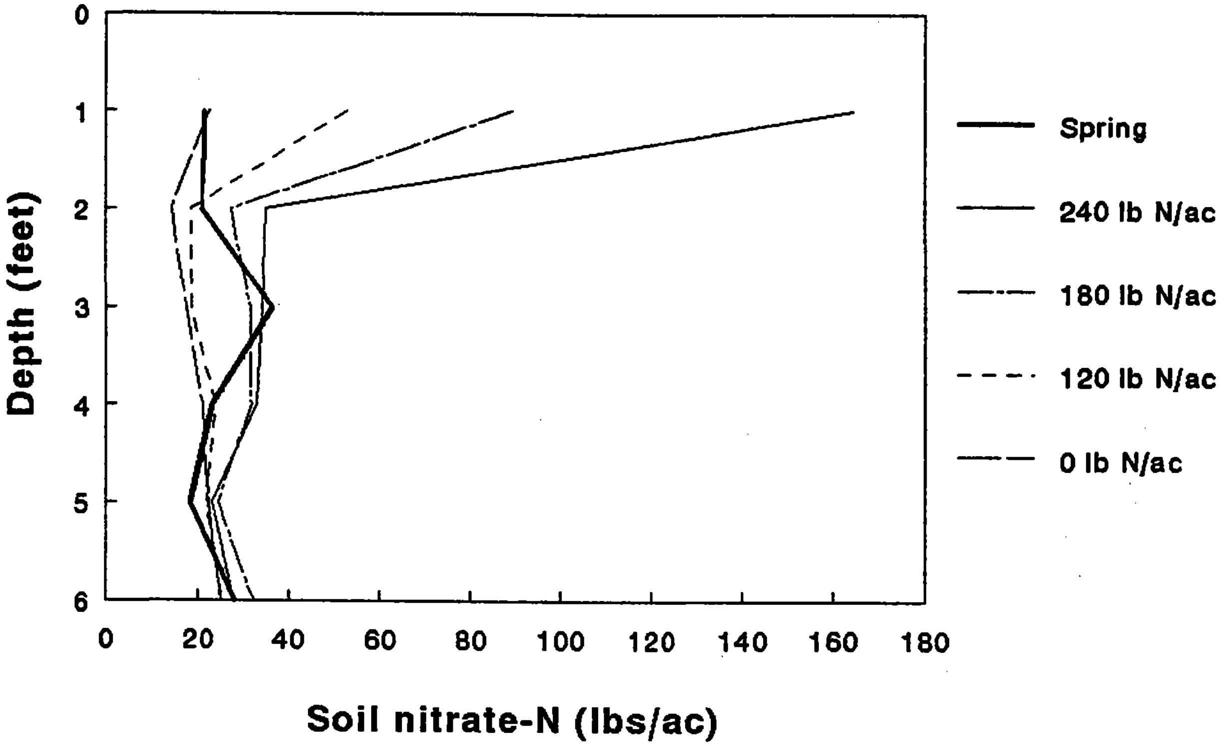


Figure 10. Influence of nitrogen fertilizer rate on residual soil nitrogen after harvest compared to pre-plant (spring) levels. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

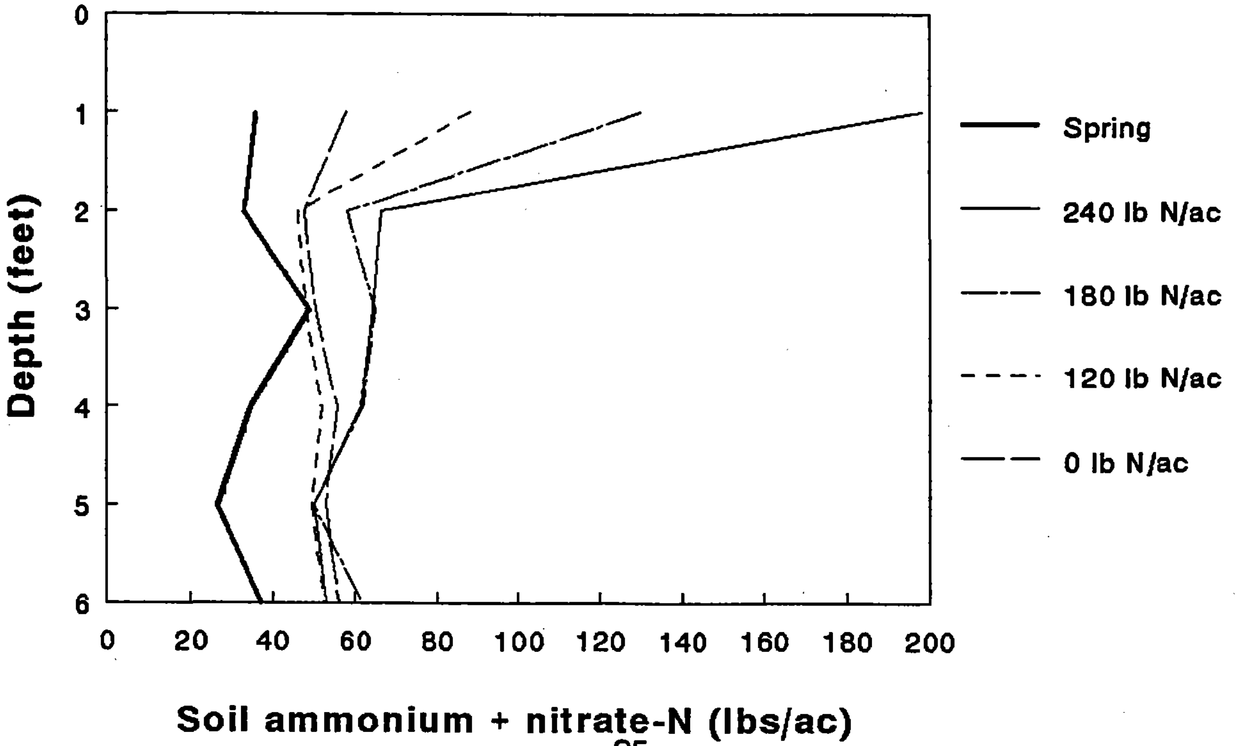


Figure 11. Influence of nitrogen fertilizer timing on residual soil nitrate after harvest compared to pre-plant (spring) levels. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

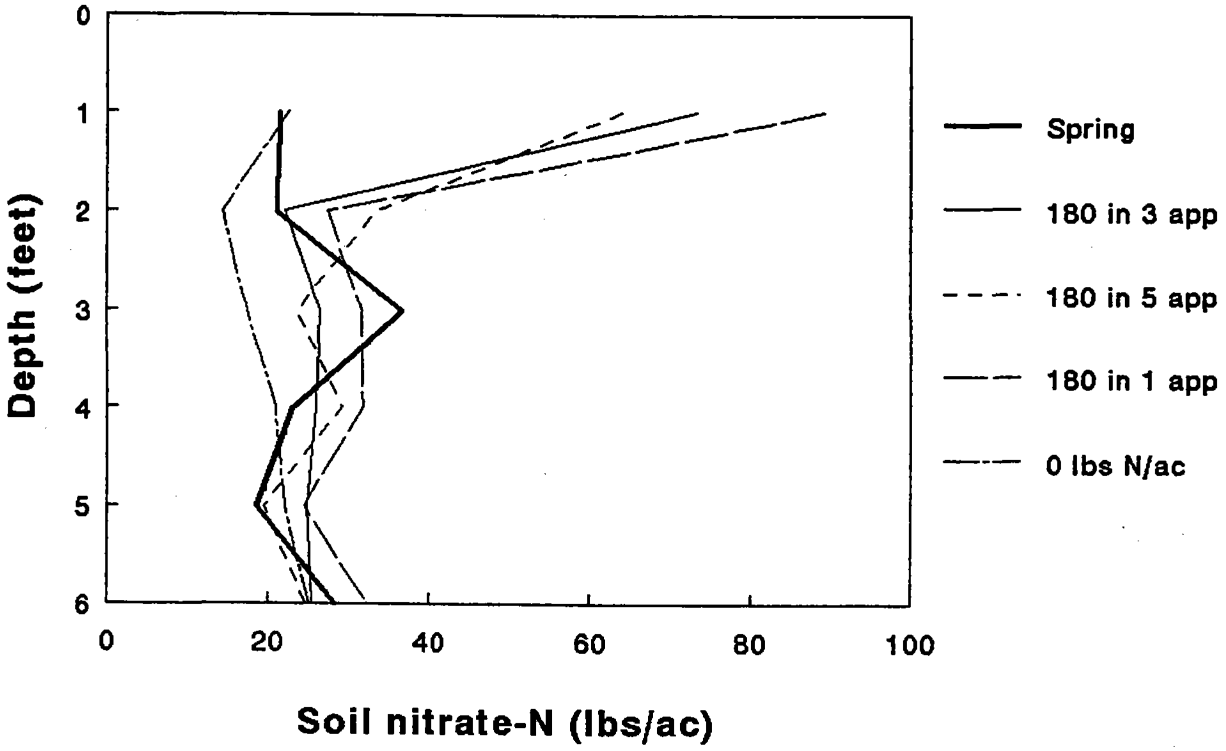
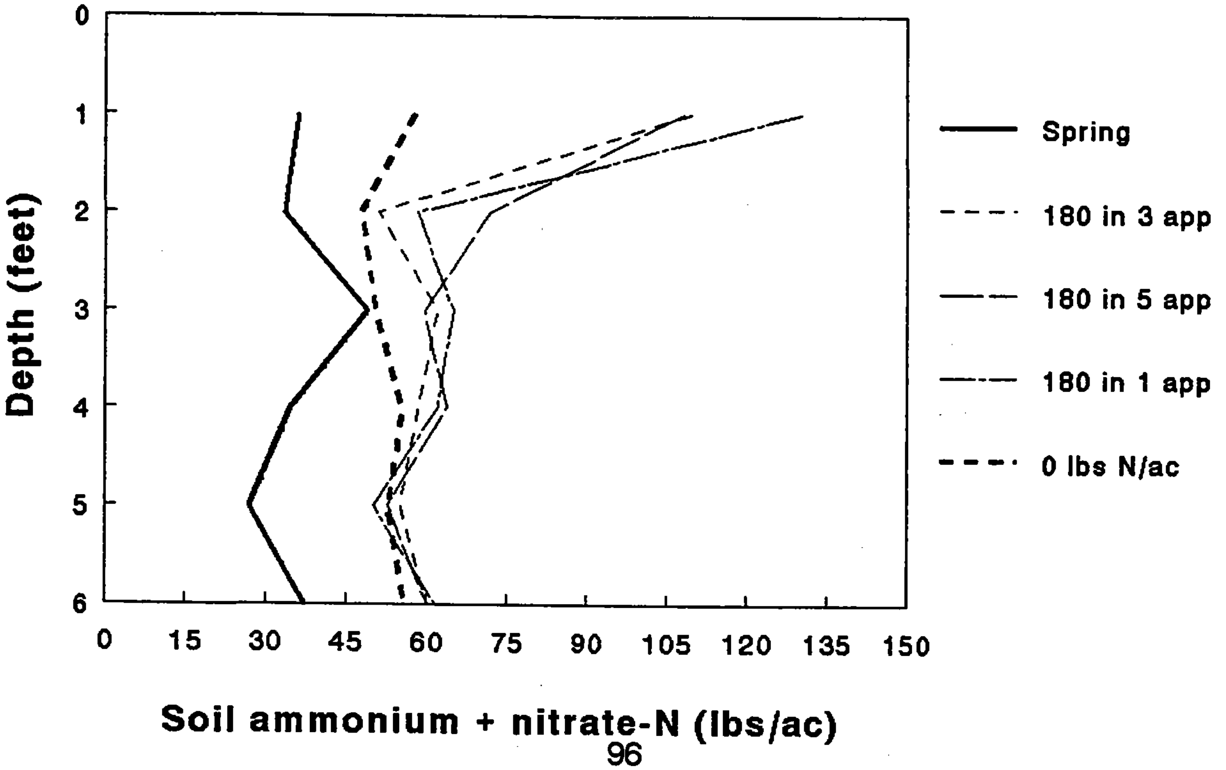


Figure 12. Influence of nitrogen fertilizer timing on residual soil nitrogen after harvest compared to pre-plant (spring) levels. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.



MECHANICAL STRAW MULCHING AND RESERVOIR TILLAGE EFFECTS ON SHEPODY POTATOES IN THE TREASURE VALLEY

Joe H. Hobson[1], Lynn Jensen[2], Keith Langley[3], Clinton C. Shock[4],
Tim D. Stieber[5], Mike Thornton[5], and Tirsa Jensen[6]
[1]Hobson Manufacturing, [2]OSU Extension, [3]Bel-Air Farms,
[4]Malheur Experiment Station, Oregon State University,
[5]University of Idaho, and [6]Malheur County SWCD

Abstract

Shepody potatoes were grown under sprinkler irrigation on sloping ground (4.2 to 8.5 percent slope) with and without mechanically applied wheat straw, grass straw, or reservoir tillage. Mechanical furrow mulching used 1,000 lb/ac of wheat straw or grass straw. Mulched, non-mulched, reservoir-tillage, and check plots were irrigated 12 times with solid set sprinklers. Compared with reservoir-tillage, furrow mulching increased average potato yields by 41 cwt (P=0.10).

Introduction

The large increase in acreage devoted to potato production in the Pacific Northwest has been possible because of the use of sprinkler irrigation on sloping ground. Since sloping topography promotes soil erosion, research was conducted by Aarstad and Miller (1973) to address the problem. They found that placing small basins or plant residues between crop rows reduced runoff from 40 percent to 1 percent and increased sugar beet and potato yields under center-pivot sprinklers. Machines and cultural practices have been developed to mechanize the construction of small basins (reservoir tillage) and apply straw mulch to furrows. Ron Yoder (1991) reported in a study of the fate of irrigation water in reservoir tillage that under sprinkler irrigation, a high percentage of the water is shed by the plant canopy and sides of the potato hill, ending up in the furrow. He also said that blue dye used in a metribuzin study clearly demonstrated that a significant portion of applied water (and chemicals in the water) ends up in the furrow instead of the root zone. Yoder observed that deep leaching below the furrow was aggravated when reservoir tillage was used. This increases the possibility of leaching materials into the aquifer.

Many machines that are used for reservoir tillage use a ripper shank in the furrow bottom that loosens the soil to make the basins. Reservoir tillage is not the only viable option to reduce runoff in potato fields.

Research has shown that mechanical furrow mulching has provided reduced runoff, increased water infiltration, and increased lateral movement of the wetting front under furrow irrigation (Shock et. al. 1988, Stieber et. al. 1991). The present study sought to compare the effects of reservoir-tillage and mechanical furrow mulching using two kinds of straw with untreated soil, for potato yield and size distribution.

Procedures

Shepody potatoes were planted in beds 3 feet apart on April 20, 1993 in a silt loam soil with a 4.25 to 8.5 percent slope. The erosion control treatments were applied after herbicide application and final cultivation on June 1, 1993. The four treatments consisted of an untreated check, mechanical furrow mulching with wheat straw or grass straw, and reservoir tillage. The plots were 100 feet long and 4 beds wide. Each treatment was replicated eight times in a randomized complete block design. Potatoes from forty feet of row were harvested from the center of each plot on August 26, 1993 and the entire harvested sample was submitted to the J.R. Simplot Co. raw laboratory for yield, grade, and quality analysis.

Results and Discussion

Mechanical furrow mulching increased Shepody potato yield an average of 41 cwt/ac over reservoir-tillage (P=0.10, Table 1). There was no significant yield difference between the wheat or grass mulch.

Mechanical furrow mulching increase of large tubers compared tot he untreated check did not reach statistical significance (Table 2).

Table 1. Effect of mechanical furrow mulching and reservoir tillage on Shepody potato yield and processor grade under solid set sprinkler irrigation. Bel Air farm Nyssa, Oregon, 1993.

Erosion control treatments	Total yield	Simplot processor market grade		
		Very smooth	Rougher	Undersized < 4 oz
	cwt/ac	---------------	%	---------------
Check	453	21.6	66.9	11.5
Wheat straw	463	16.4	71.6	12.0
Grass straw	469	18.8	71.6	9.6
Reservoir-tillage	425	21.0	71.3	7.7
LSD (0.10)	372	ns	ns	ns

Table 2. Effect of mechanical furrow mulching and reservoir-tillage on tuber size distribution in Shepody potatoes under solid set sprinkler irrigation. Bel Air farm Nyssa, Oregon, 1993.

Erosion control treatments	Tuber size distribution				All tubers > 6 oz
	< 4 oz	4-6 oz	6-10 oz	> 10 oz	
	%				
Check	7	10	23	58	81
Wheat straw	7	7	24	62	86
Grass straw	5	9	20	66	86
Reservoir-tillage	6	9	24	61	85
LSD (0.05)	ns	ns	ns	ns	ns

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SIMULATED HAIL TIMING: INFLUENCE ON YIELD AND QUALITY OF THREE POTATO CULTIVARS

Erik Feibert, Clint Shock and Monty Saunders
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Introduction

Hail is a potential threat during every cropping season. Potato growers and the insurance industry are interested in having an accurate method for estimating potato crop loss due to hail. The new varieties Shepody and Frontier Russet are assuming increasing economic importance, but very little is known about their relative response to hail damage compared with Russet Burbank. This trial evaluates the three varieties for their response to simulated hail damage.

Procedures

Twenty pounds of N/ac and 100 pounds of P_2O_5/ac as monoammonium phosphate, plus 10 pounds of Z/ac as zinc sulphate, were broadcast on an Owyhee silt loam in the fall of 1992 at the Malheur Experiment Station. A soil sample taken from the top foot on April 15, 1993 showed a ph of 7.3, 1.5 percent organic matter, 8 CEC, 8 ppm nitrate-N, and 7 ppm ammonium-N, (total of 45 lbs N/ac), 26 ppm phosphorus, 569 ppm potassium, 2,900 ppm calcium, 280 ppm magnesium, 257 ppm sodium, 7.1 ppm zinc, 7.2 ppm iron, 14.4 ppm manganese, 1.3 ppm copper, 7 ppm sulfur, and 0.6 ppm boron. The field was bedded into 36-inch hills in the spring of 1993. Prowl at 1 lb ai/ac and Dual at 2 lbs ai/ac were sprayed on May 6 and incorporated during planting. Two ounce seed pieces of Russet Burbank, Shepody, and Frontier Russet were planted May 7 at 9-inch spacing. On May 14, urea at 45 lbs N/ac and Thimet 20G at 3 lbs ai/ac were sidedressed. Bravo 500 at 0.6 pint ai/ac was applied for preventive control of leaf fungi, plus Uniroyal ZKP, on June 25. Petiole samples from Russet Burbank plants were collected from the check plots every two weeks during tuber bulking to help keep nitrogen non-limiting. Due to low petiole nitrate levels the trial was fertilized with Uran at 30 lbs N/ac on July 5 and July 20, and at 20 lbs N/ac on July 30.

The crop was irrigated with a solid set sprinkler system with nozzles spaced 40 feet by 42 feet. Fifteen granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200SS, Irrometer Co., Riverside, CA) were used to measure soil water potential in the check (no hail) plots. Granular matrix sensors were offset 6 inches from the hill center and centered 8 inches below the hill surface (top of GMS was 6 inches from the soil surface). Granular matrix sensors had been previously calibrated to soil water potential. Sensors were read five times per week from June 14 to September 3. The crop was irrigated when soil water potential in the first foot reached -60 kPa. Due to an unusually wet winter and spring the soil water potential in the second foot of soil was -16 kPa and in the first foot of soil was -38 kPa on June 14. This indicated a substantial amount of water in the profile that could be available to the plant by a combination of upward capillary movement and root absorption. This resulted in the GMS responding slower than expected to the potato evapotranspiration (ET_c) calculated from the AgriMet weather station. Consequently, in order to keep the top foot GMS below -60 kPa, less water than the accumulated ET_c was required. It was decided then that water application would be limited to 1.2 inches when, according to the GMS data, irrigations would be necessary. Consequently, only the first three irrigations had 100 percent of ET_c replaced by irrigation. The crop received a total of 14 ac-inches of water from irrigation and rainfall with ET_c of 19 ac-inches.

The experimental design was a split plot with the four hail treatments as the main plots, and the three varieties as split plots within the main plots. Each plot was 40 feet long by 7 rows wide. The three varieties were planted in the center three rows of the plot with two rows of Russet Burbank as border on each side. The hail timing treatments were completely randomized within each of the six replicates. The varieties were randomized within each plot.

The four hail treatments consisted of three simulated hail dates (July 2, July 23, August 13) and a non-hailed check treatment. Each plot in each hail treatment received hail only once. The hail consisted of cubed ice being blown through a flexible plastic tube onto the three middle potato rows of the plot. Approximately 1 lb of cubed ice per square foot was used for each hail treatment. Prior to each hail treatment, one typical plant of each variety in nine unhailed plots throughout the field was sampled and evaluated for stem height, number of stems, number of nodes on main stem, length of largest tuber, number of tubers, and total tuber weight. The total number of viable leaves on the main stem were counted immediately after each hail treatment for five plants of each variety in each hailed plot and in each check plot.

Thirty-six feet were harvested from each of the three middle rows in each plot on September 29. The tubers were graded and a 40 tuber subsample was stored and analyzed for tuber specific gravity and stem-end fry color.

Results and Discussion

Potato vegetative characteristics prior to each hail treatment and percent leaf loss to hail are shown in Table 1. The interpretation of the vegetative characteristics in terms of growth stage according to the National Crop Insurance Services guidelines (anonymous, 1990, Table 2) is shown in Table 3. In addition to leaf loss the plants suffered substantial stem bruising and some stem breakage. Russet Burbank was the tallest variety, had the most nodes on the main stem, and the highest hill weight except on August 13. Shepody had the longest tubers on all hail dates.

Soil water potential was inadvertently allowed to go below -60 kPa once in late June (Figure 1). US Number One tuber yields and stem-end fry color could have been better if soil water potential had remained above -60 kPa all season. Petiole nitrate levels dipped below adequate levels according to established guidelines (Jones and Painter, 1974) on June 30 (Figure 2). Nitrogen fertilization on July 5, 20, and 30 maintained plant vigor.

The hail treatments resulted in significant losses in both yield and grade (Tables 4 and 5 respectively). The decreases in marketable yield were greater than the decreases in total yield, specially for Russet Burbank and Frontier Russet, due to an increased proportion of undersized tubers with hail (Table 5). The July 23 (late July) hail date was among the lowest in total and marketable yield, and yield of US Number One tubers in relation to the check for all three varieties. In 1992, the late July treatment was also among the lowest in US Number One tuber yield for all varieties. Over all varieties, the late July hail resulted in the highest amount of undersize tubers, reflecting the abrupt cessation of tuber growth with weak regrowth. The late July and mid August treatments were among the lowest in total and marketable tuber yield in 1992 (Table 6). For Russet Burbank and Shepody, the August 13 hail date was among those resulting in the least reduction in US Number One tuber yield and grade. For Frontier Russet the July 2 hail date was among those resulting in the least reduction in US Number One tuber yield and grade. From visual observations it was found that the plants hailed on at the earliest date recovered the quickest and most vigorously. The plants hailed on at the last date never recovered.

The July 23 hail treatment was among the lowest in stem-end fry color for all varieties (Table 5). Shepody had the lightest frying tubers on all hail dates. The July 23 and the August 13 hail treatments were among the lowest in specific gravity (Table 5).

The estimated tuber yield at each plant growth stage is shown in Table 1 and Figure 3. The plants in this trial were found to recover from the hail damage by producing new leaves and resuming growth, especially after the first two hail dates. Potato fields that have suffered hail damage are susceptible to diseases that can rapidly kill the plants. If potato plants had died at the time of hail treatments, both yield and tuber size would have been severely reduced. However, actual yield reductions in July hail-damaged plots were much less than the plant growth data would suggest, mainly due to rapid recovery of plants after July hail damage.

The results of the 1992 and 1993 trial show that the late July hail treatment resulted in the largest losses in yield for all varieties (Tables 6 and 7). The early July and mid-August hail treatments resulted in similar losses in yield in both years. The potato plants hailed in early July regrew vigorously and hence still had time to use the remainder of the season for tuber bulking (Figure 3). The plants hailed in late July did not regrow as vigorously and hence probably were not able to resume tuber bulking. The plants hailed in mid-August did not regrow , but most of the seasons' tuber bulking had already taken place.

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Jones, J.P. and Painter, C.G., 1974. Tissue analysis: A guide to nitrogen fertilization of Idaho Russet Burbank Potatoes. University of Idaho, College of Agriculture, Cooperative Extension Service, Agricultural Experiment Station, Current information series # 240, June 1974.

Table 1. Potato vegetative characteristics at the time of each simulated hail treatment and at the final harvest, and leaf loss caused by simulated hail treatments. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Hail date/ DAI§	Plant height	# of stems/plant	# of nodes on main stem	Length of largest tuber	# of tubers/plant	Hill weight	Av. tuber weight	Leafloss	Est. yield
		in			in		----- oz. -----		%	cwt/ac
R. Burbank	July 2/21§	23.1	3.6	12.4	2.1	8.8	4.0	0.5	90	48.4
	July 23/42§	33.6	3.7	16.2	4.3	7.9	19.7	2.5	90	238.4
	August 13/63§	32.6	3.9	16	5.4	7.1	31.5	4.4	90	381.1
	September 29/110§					7.1	43.5	6.1		527.2
Shepody	July 2/19§	18.6	2.6	11.3	2.2	7.5	3.8	0.5	90	46.0
	July 23/40§	29.1	2.4	14.7	4.6	4.3	17.9	4.2	90	216.6
	August 13/61§	29.1	2.4	13.7	5.6	4.2	35.7	8.5	90	432.0
	September 29/108§					4.2	38.2	9.1		462.1
F. Russet	July 2/19§	14.2	2.6	9	1.0	8.9	0.6	0.1	90	7.3
	July 23/40§	28.8	3.1	13.9	3.3	7.4	16.9	2.3	90	205.5
	August 13/61§	28.7	2.9	12.7	4.5	5.6	29.7	5.3	90	359.4
	September 29/108§					5.6	34.6	6.2		418.6

§ DAI, days after the onset of tuber initiation.

Table 2. White potato stage-of-growth chart from the National Crop Insurance Services potato loss instructions pg. 4, 1990.

White potato
stage of growth chart

Stage	Canopy	Height	Tuber	Hill wt
Emergence	none	1/2	seed	
V-1	Vegetative growth only, determine by actual measure	2-5	seed	
V-2	Vegetative growth with 6-8 discernible nodes on the	5-8	seed	
R-1	10-12 discernible nodes, small buds at the very top of	10-16	¼"-½"	0.6
R-2	Primary inflorescence shows above leaves, many buds,	16-20	½"-1"	2.7
R-3	Secondary shoots starting to elongate, growth of plant	20-24	1"-1½"	8.0
R-4	Blossoms on primary inflorescence open, secondary	24-28	1½"-2"	15.3
R-5	Most flowers on the primary inflorescence open and	28-32	2"-3"	21.6
R-6	Majority of the first blooms have fallen. Secondary	32-36	3"-3½"	27.9
R-7	All primary and most secondary flowers have fallen,	36-40	3½"-4"	34.2
R-8	Considerable lateral vine growth, two or more third-	40-42	tubers to 8	40.5
R-9	All blooms will have fallen, leaves starting to change	42-44	80% of	45.0
R-10	Lower leaves will be yellowish, no blossoms present	48-48	tubers to 10	48.4
R-11	All leaves have become yellow, leaves starting to fall	"	most tubers	49.5
R-12	All leaves drying, many leaves have fallen	"	fully mature	51.0

Table 3. Growth stage of three potato varieties at three simulated hail application dates according to Table 2. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Hail date/DAI*	Height	Canopy Description	Tuber Size	Hill Weight	Average[1]
R. Burbank	July 2/21	R-3	R-4	R-5	R-2	R-3.5
	July 23/42	R-6	R-6	R-7	R-5	R-6
	August 13/63	R-6	R-9	R-8	R-6	R-7.25
Shepody	July 2/19	R-2	R-4	R-5	R-2	R-3.25
	July 23/40	R-5	R-6	R-7	R-5	R-5.75
	August 13/61	R-5	R-9	R-8	R-7	R-7.25
Frontier R.	July 2/19	R-1	R-3	R-3	R-1	R-2
	July 23/40	R-5	R-6	R-6	R-4	R-5.25
	August 13/61	R-5	R-8	R-8	R-6	R-6.75

* DAI, days after the onset of tuber initiation

[1] Average of canopy description, tuber size and hill weight

Table 4. Yield response of three potato cultivars to simulated hail timing. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

		Potato yield by market grade										
		#1				#2						
Variety	Treatment	4-6 oz	6-10 oz	>10 oz	Total	6-10 oz	>10 oz	Total	Total Marketable	Undersize	Rot	Total Yield
		cwt/ac										
R. Burbank	No hail	90.9	152.7	112.2	355.8	34.9	21.2	56.1	411.9	114.7	0.65	527.2
	Hail on 7-2	103.2	124.0	68.9	296.2	29.1	15.8	44.9	341.1	119.8	0.81	461.7
	Hail on 7-23	91.0	52.3	46.5	189.7	42.5	28.1	70.6	260.3	126.9	1.89	389.1
	Hail on 8-13	113.0	131.1	79.3	323.4	27.1	11.9	39.0	362.4	108.6	0.47	471.5
Shepody	No hail	39.7	72.7	234.0	346.5	24.2	50.7	75.0	421.5	39.9	0.78	462.1
	Hail on 7-2	44.3	78.9	156.3	279.6	25.1	49.1	74.2	353.8	51.7	1.71	407.1
	Hail on 7-23	39.7	82.5	141.9	264.1	17.9	25.4	43.3	307.4	44.0	0.43	351.8
	Hail on 8-13	41.5	76.5	171.4	289.3	24.8	35.8	60.5	349.9	37.8	1.15	388.8
F. Russet	No hail	66.2	101.4	117.8	285.5	24.5	29.7	54.2	339.7	76.8	2.09	418.6
	Hail on 7-2	57.8	106.8	79.2	243.8	19.3	29.3	48.6	292.4	82.0	0.58	375.0
	Hail on 7-23	58.9	61.9	44.9	165.7	26.8	28.7	55.5	221.3	100.9	4.19	326.3
	Hail on 8-13	60.8	93.8	64.0	218.6	21.3	18.9	40.2	258.8	89.2	2.58	350.5
Average	No hail	65.6	109.0	154.7	329.3	27.9	33.9	61.8	391.1	77.1	1.17	469.3
	Hail on 7-2	68.4	103.2	101.5	273.2	24.5	31.4	55.9	329.1	84.5	1.03	414.6
	Hail on 7-23	63.2	65.5	77.8	206.5	29.1	27.4	56.5	263.0	90.6	2.17	355.8
	Hail on 8-13	71.8	100.4	104.9	277.1	24.4	22.2	46.6	323.7	78.5	1.40	403.6
LSD(0.05) Treatment		17.7	20.9	39.1	48.4	7.8	ns	ns	59.9	ns	ns	66.4
LSD(0.05) Variety		ns	21.1	29.7	26.2	ns	10.8	ns	25.7	21.6	3.72	29.2
LSD(0.05) Treatment X Var.		ns	42.1	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 5. Tuber market grade and tuber quality response of three potato cultivars to simulated hail timing. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

		Potato market grade distribution											
		#1				#2							
Variety	Treatment	4-6 oz	6-10 oz	> 10 oz	Total	6-10 oz	> 10 oz	Total	Marketable	Undersize	Rot	Stem-end fry color	Specific gravity
		%										% reflect.	
R. Burbank	No hail	17.1	28.1	22.1	67.3	6.9	4.1	11.0	78.3	21.5	0.15	36.1	1.092
	Hail on 7-2	22.2	26.2	16.6	65.0	6.3	3.5	9.8	74.8	25.1	0.16	39.3	1.096
	Hail on 7-23	25.3	13.4	10.8	49.5	10.5	6.9	17.4	66.9	32.5	0.56	35.4	1.085
	Hail on 8-13	24.1	27.4	17.0	68.4	5.6	2.6	8.2	76.6	23.3	0.09	36.0	1.082
Shepody	No hail	8.5	15.9	50.6	75.0	5.2	11.1	16.2	91.2	8.6	0.18	41.9	1.084
	Hail on 7-2	10.7	19.4	38.5	68.7	6.1	12.3	18.4	87.1	12.4	0.44	42.4	1.088
	Hail on 7-23	11.7	23.9	40.0	75.6	4.9	7.3	12.2	87.8	12.1	0.15	37.8	1.080
	Hail on 8-13	10.0	19.7	45.2	75.0	6.2	9.2	15.3	90.3	9.4	0.37	41.8	1.082
F. Russet	No hail	16.0	24.1	27.9	67.9	5.8	7.1	12.9	80.7	18.7	0.51	31.1	1.088
	Hail on 7-2	15.5	28.2	21.5	65.1	5.0	7.7	12.7	77.9	22.0	0.17	33.9	1.095
	Hail on 7-23	19.1	19.5	13.5	52.2	7.4	7.5	14.8	67.0	31.9	1.11	32.7	1.093
	Hail on 8-13	17.3	26.7	18.2	62.2	5.9	5.5	11.4	73.6	25.6	0.81	28.5	1.078
Average	No hail	13.8	22.7	33.5	70.1	5.9	7.4	13.4	83.4	16.3	0.28	36.4	1.088
	Hail on 7-2	16.1	24.6	25.5	66.3	5.8	7.8	13.6	79.9	19.8	0.26	38.5	1.093
	Hail on 7-23	18.7	18.9	21.4	59.1	7.6	7.2	14.8	73.9	25.5	0.61	35.3	1.086
	Hail on 8-13	17.1	24.6	26.8	68.5	5.9	5.7	11.6	80.2	19.4	0.42	35.4	1.081
LSD(0.05) Treatment		ns	3.7	5.9	4.0	ns	ns	ns	2.9	2.9	ns	2.96	0.0036
LSD(0.05) Variety		3.7	3.7	7.4	4.4	ns	2.8	2.9	4.1	4.2	ns	2.10	0.0025
LSD(0.05) Trt X Var.		ns	7.4	ns	8.7	ns	ns	5.8	ns	ns	ns	ns	ns

Table 6. Two-year averages of yield response of three potato cultivars to simulated hail timing. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

		Potato yield by market grade								
		US #1 total			Total marketable			Total		
Variety	Hail timing	1992	1993	Avg.	1992	1993	Avg.	1992	1993	Avg.
		cwt/ac								
R. Burbank	No hail	257.7	355.8	306.8	375.1	411.9	393.5	449.4	527.2	488.3
	Early July	218.8	296.2	257.5	398.4	341.1	369.8	463.9	461.7	462.8
	Late July	201.2	189.7	195.5	346.8	260.3	303.6	432.7	389.1	410.9
	Mid August	235.4	323.4	279.4	339.2	362.4	350.8	404.7	471.5	438.1
Shepody	No hail	366.5	346.5	356.5	450.4	421.5	436.0	510.0	462.1	486.1
	Early July	393.3	279.6	336.5	444.5	353.8	399.2	502.3	407.1	454.7
	Late July	300.1	264.1	282.1	395.6	307.4	351.5	472.9	351.8	412.4
	Mid August	369.4	289.3	329.4	409.7	349.9	379.8	482.0	388.8	435.4
F. Russet	No hail	340.6	285.5	313.1	358.3	339.7	349.0	421.7	418.6	420.2
	Early July	319.7	243.8	281.8	336.5	292.4	314.5	410.2	375.0	392.6
	Late July	287.6	165.7	226.7	302.6	221.3	262.0	385.7	326.3	356.0
	Mid August	289.5	218.6	254.1	300.3	258.8	279.6	369.5	350.5	360.0
Average	No hail	321.6	329.3	325.5	394.6	391.0	392.8	460.4	469.3	464.9
	Early July	310.6	273.2	291.9	393.1	329.1	361.2	458.8	414.6	436.7
	Late July	263.0	206.5	234.8	348.3	263.0	305.7	430.4	355.7	393.1
	Mid August	298.1	277.1	287.6	349.7	323.7	336.7	418.7	403.6	411.2
LSD(0.05) Trt		37.5	48.4		39.7	59.9		42.1	66.4	
LSD(0.05) Var		25.5	26.2		24.4	25.7		29.1	29.2	
LSD(0.05) Trt X Var		ns	ns		ns	ns		ns	ns	

Table 7. Two-year averages of US Number One tuber grade and tuber quality response of three potato cultivars to simulated hail timing. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

		US #1 total			Stem-end fry color			Specific gravity		
		1992	1993	Avg.	1992	1993	Aver.	1992	1993	Avg.
Variety	Hail timing	----- % -----			--- % reflectance ---					
R. Burbank	No hail	57.3	67.3	62.3	38.4	36.1	37.3	1.084	1.092	1.088
	Early July	47.3	65.0	56.2	38.0	39.3	38.7	1.085	1.096	1.091
	Late July	47.1	49.5	48.3	33.0	35.4	34.2	1.081	1.085	1.083
	Mid August	57.9	68.4	63.2	35.2	36.0	35.6	1.080	1.082	1.081
Shepody	No hail	72.1	75.0	73.6	47.7	41.9	44.8	1.083	1.084	1.084
	Early July	78.2	68.7	73.5	47.3	42.4	44.9	1.083	1.088	1.086
	Late July	63.3	75.6	69.5	45.9	37.8	41.9	1.080	1.080	1.080
	Mid August	76.2	75.0	75.6	47.6	41.8	44.7	1.080	1.082	1.081
F. Russet	No hail	80.9	67.9	74.4	35.6	31.1	33.4	1.088	1.088	1.088
	Early July	74.7	65.1	69.9	36.3	33.9	35.1	1.084	1.095	1.090
	Late July	77.9	52.2	65.1	36.6	32.7	34.7	1.087	1.093	1.090
	Mid August	78.0	62.2	70.1	36.8	28.5	32.7	1.082	1.078	1.080
Average	No hail	70.1	70.1	70.1	40.6	36.4	38.5	1.085	1.088	1.087
	Early July	66.7	66.3	66.5	40.5	38.5	39.6	1.084	1.093	1.089
	Late July	62.8	59.1	61.0	38.5	35.3	36.9	1.083	1.086	1.084
	Mid August	70.7	68.5	69.6	39.9	35.4	37.7	1.081	1.081	1.081
LSD(0.05) Trt		5.3	4.0		ns	3.0		0.004	0.0036	
LSD(0.05) Var		2.1	4.4		1.8	2.1		0.002	0.0025	
LSD(0.05) Trt X Var		4.3	8.7		ns	ns		ns	ns	

Figure 1. Soil water potential in the first foot of soil over time in check plots without hail in hail timing trial. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

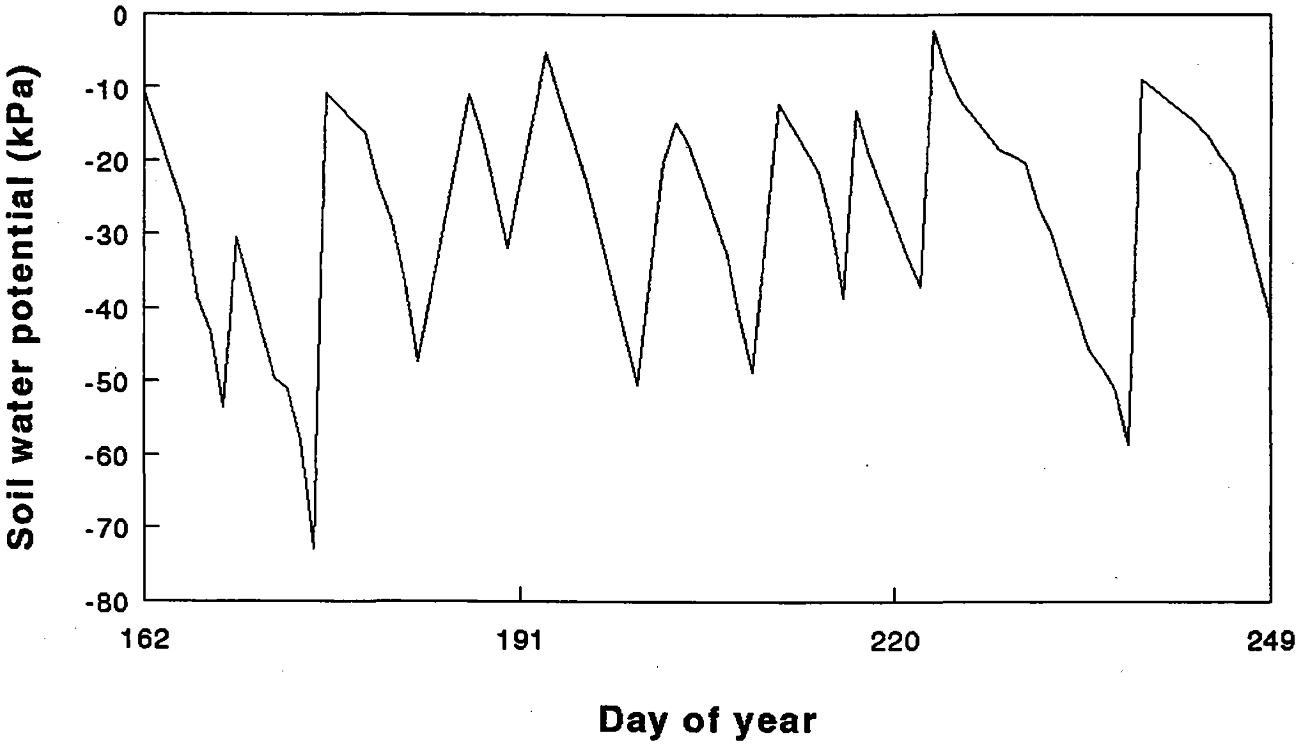


Figure 2. Russet Burbank leaf petiole nitrate content (in thousands of ppm) over time in the check plots without hail in hail timing trial. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

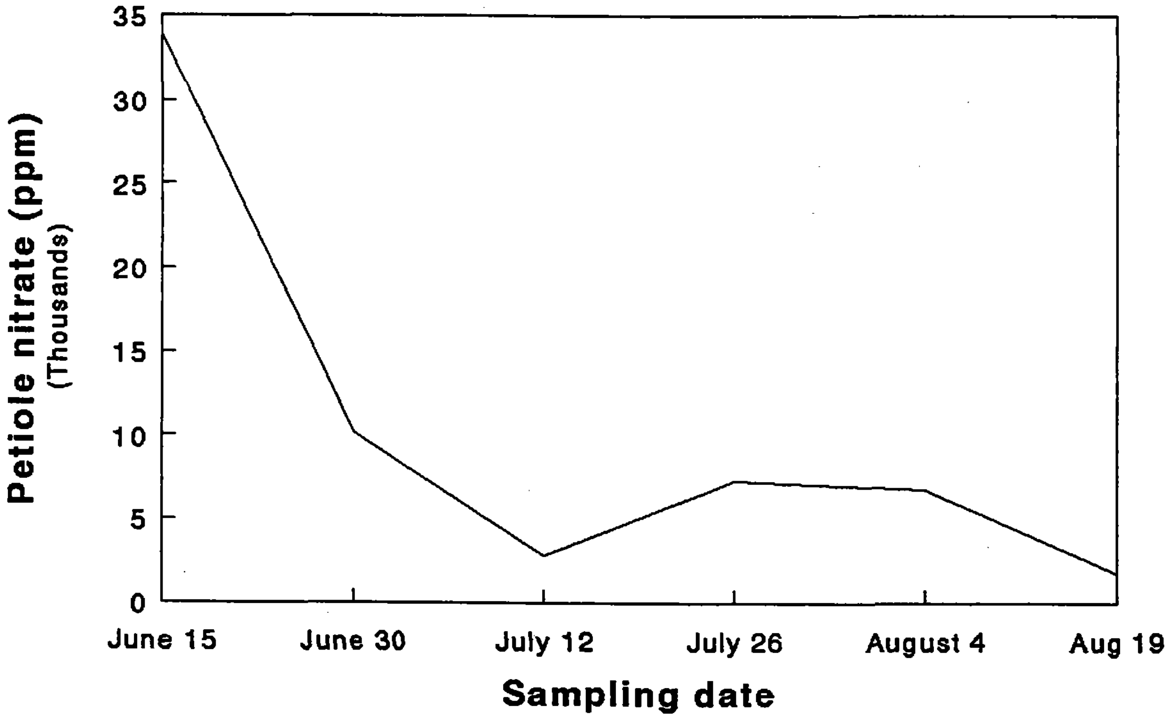
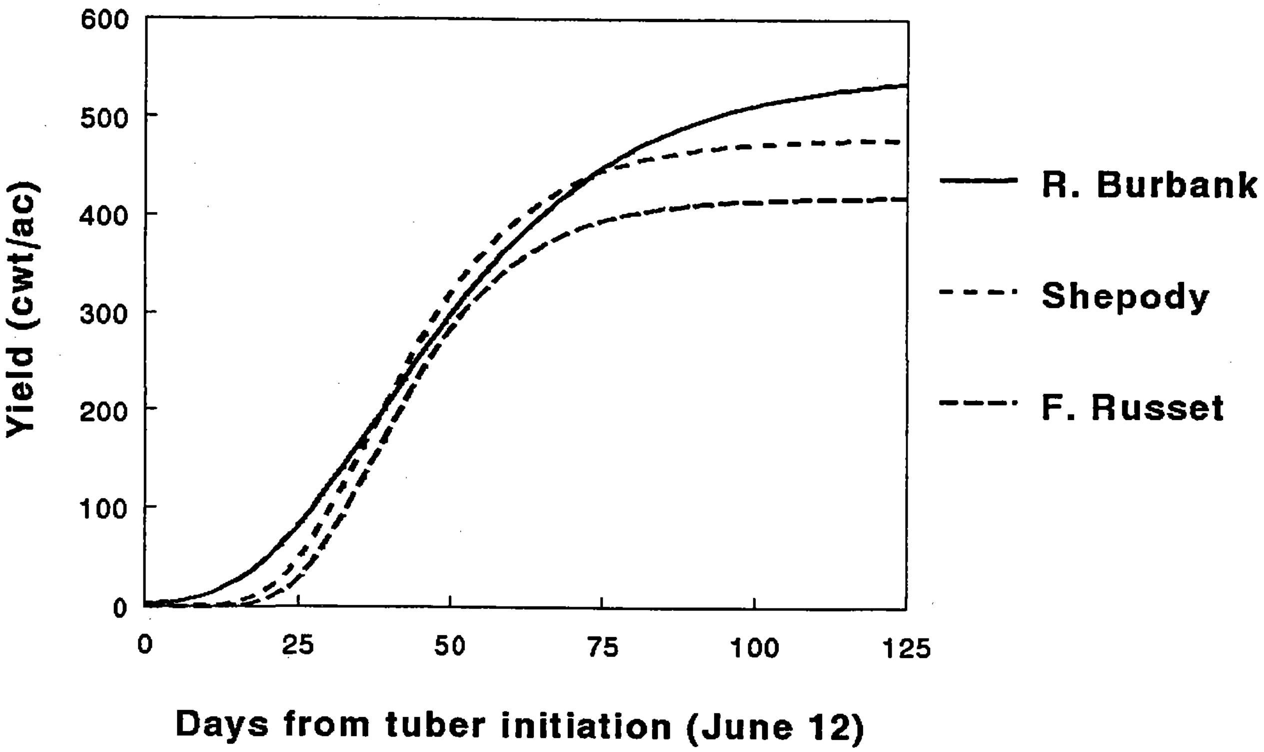


Figure 3. Tuber development over time for three potato cultivars without hail. Days are the number of days from the onset of tuber initiation, June 12, 1993. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.



EFFECT OF FOLIAR METHANOL APPLICATIONS ON POTATO YIELD AND QUALITY

Erik Feibert, Clint Shock and Lamont Saunders
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Introduction

Nonomura and Benson (1992) have recently reported increases in growth and yield of C3 plants in response to foliar applied methanol. The trials were conducted in Arizona and responses were only found for methanol applied in the summer and under full sunlight. Since potatoes are a C3 plant, we wanted to test whether potato yield and quality could be increased by using foliar applied methanol.

Procedures

Twenty pounds of N/ac and 100 pounds of P_2O_5/ac as monoammonium phosphate, plus 10 pounds of Zn/ac as zinc sulphate, were broadcast on an Owyhee silt loam in the fall of 1992 at the Malheur Experiment Station. The field was bedded into 36-inch hills in the spring of 1993. Prowl at 1 lb ai/ac and Dual at 2 lbs ai/ac were sprayed on May 6 and incorporated after planting. Two-ounce seed pieces of cv. Russet Burbank were planted May 7 at 9-inch spacing. On May 14, urea was sidedressed at 60 lbs N/ac along with Thimet 20G at 3 lbs ai/ac. Bravo 500 at 0.6 pint ai/ac plus Uniroyal ZKP was applied for preventive control of leaf fungi on June 25.

The treatments consisted of five methanol solutions and a check (Table 1). Plots were five rows wide and 30 feet long, and were arranged in a randomized complete block design with five replicates. The methanol solutions were applied to four rows in each plot with a backpack sprayer with four 8002 LP nozzles spaced 18 inches apart. Plots were sprayed on July 9, August 6, and August 19 between 1 and 4 p.m. Maximum and minimum air temperatures recorded at the Malheur Experiment Station weather station were 81 °F and 48 °F on July 9, then 93 °F and 56 °F on August 6. The month's average maximum and minimum air temperatures were 80 °F and 50 °F, for July, 84 °F and 50 °F for August, and 81 °F and 44 °F for September.

The trial was irrigated with a solid set sprinkler system with nozzles spaced 40 feet by 50 feet. Fifteen granular matrix sensors (GMS, Watermark Soil Moisture Sensors Model 200, Irrometer Co., Riverside, CA) were used to measure soil water potential. Sensors were offset 6 inches from the hill center and centered 8 inches below the hill surface (top of GMS was 6 inches from hill surface). Sensors had been previously calibrated to soil water potential. Watermarks were read five times per week from June 14 to September 3. The trial was irrigated when soil water potential in the first foot reached -60 kPa. One hundred percent of all accumulated potato evapotranspiration (ET_c) since the last irrigation as indicated by the AgriMet weather station was applied at each irrigation.

Petiole samples were collected every two weeks during tuber bulking to help keep nitrogen non-limiting. Petiole nitrate levels were 27,867 ppm on June 15, 8,664 ppm on July 12, 6,664 ppm on August 4, and 11,580 ppm on August 19. A total of 110 lbs of N/ac as Uran was run through the sprinkler system during the season.

All tubers from 24 feet of the middle two rows were harvested October 3 and evaluated for yield and grade. A representative 40 tuber subsample was stored for determination of tuber specific gravity, and stem-end fry color in early November.

Results and Discussion

The methanol treatments did not result in any significant difference in tuber yield, grade, stem-end fry color, or specific gravity.

A continuation of this research under warmer conditions would be more analogous to the experimental conditions of Nonomura and Benson. The summer of 1993 was unusually cool. The maximum air temperature never reached 100 °F. Maximum air temperatures above 104 °F were reported to be common during the trials conducted by Nonomura and Benson.

Due to the considerable expense of methanol applications and the absence of yield responses, growers are cautioned that field applications of methanol will raise potato crop production costs without the likelihood of yield enhancements.

Table 1. Methanol treatments applied to Russet Burbank potatoes. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment	Methanol concentration	Triton X-100 concentration*	Total application volume
	-------------- %	--------------	gal/ac
1	0 (check)	0	0
2	20	0.1	65
3	40	0.1	65
4	80	0.1	65
5	20	0	65
6	40	0	65

* 1% for first application

Table 2. Effect of foliar applications of methanol on Russet Burbank potato yield and quality. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

% methanol concentration	Triton x-100	Potato yield by market grade											
		US Number One				US Number Two				Total marketable	Rot	Undersize	Total yield
		4-6 oz	6-10 oz	>10 oz	total	4-6 oz	6-10 oz	>10 oz	total				
		cwt/ac											
0	-	107.4	122.8	49.0	279.3	23.9	33.7	16.0	73.6	352.9	1.6	118.3	472.9
20	+	105.5	104.8	32.5	242.9	27.0	21.0	14.2	62.1	305.0	1.4	124.1	430.5
40	+	102.0	114.1	48.4	264.5	33.6	31.0	15.6	80.2	344.7	1.5	117.5	463.7
80	+	98.4	109.9	55.4	263.7	22.9	24.0	16.3	63.2	326.8	0.8	117.2	444.8
20	-	91.2	127.5	64.7	283.3	26.4	31.7	26.7	84.8	368.1	1.3	118.5	487.9
40	-	89.2	118.1	51.8	259.1	31.7	32.5	25.1	89.4	348.5	1.0	120.6	470.1
LSD(0.05) Trt.		ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns

Table 3. Effect of foliar applications of methanol on tuber stem-end fry color and specific gravity. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

% methanol concentration	Triton x-100	Stem-end fry color	Specific gravity
		% reflectance	
0	-	37.7	1.084
20	+	38.7	1.084
40	+	39.5	1.086
80	+	39.1	1.084
20	-	39.0	1.085
40	-	38.3	1.084
LSD (0.05) Treatment		ns	ns

Literature cited

Nonomura, A.M. and A.A. Benson, 1992. Proc. Natl. Acad. Sci. U.S.A. Vol. 89, pp. 9794-9798

SOYBEAN RESEARCH AT ONTARIO IN 1993

Clint Shock, Erik Feibert, and Monty Saunders
Malheur Experiment Station
Oregon State University
Ontario, Oregon

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 be exported to the Orient, and provide raw material for specialized food products here. Soybean would also be a valuable rotation crop because of the soil improving qualities of its residues and N_2-fixing capability.

Because of the irrigated cropping patterns in the Snake River valley, soybeans may be economically feasible only at high yields. Hoffman and Fitch (1972) demonstrated that soybean cultivars adapted to Minnesota could yield 50 to 65 bushels/acre at Ontario. The most productive lines averaged 60-65 bushels/acre for several years. Furthermore, yields were increased by approximately 20 percent for certain cultivars by decreasing row widths to 22 inches. Yields can also be increased by increasing the seeding rate from 200,000 seeds/ac to 300,000 seeds/ac.

Soybean varieties developed for the midwestern and southern states are not necessarily well adapted to Oregon due to lower night temperatures, lower relative humidity, and other climatic differences. Previous research at Ontario has shown that, compared to the commercial cultivars bred for the midwest, plants for 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). In addition there is a need to identify cultivars that will grow and yield well under high seeding rates and narrow row spacing.

This report summarizes work done in 1993 as part of the continuing breeding program to adapt soybeans to Eastern Oregon.

Procedures

The trial was conducted on a silt loam previously planted to spring wheat. The field was moldboard plowed in the fall of 1992, and groundhogged and bedded in the spring of 1993. Dual at 2 lbs ai/ac was sprayed and incorporated with a bed harrow on May 21. Seed of the different cultivars was planted on May 22 at 300,000 seeds/acre in rows 22 inches apart. Rhizobium japonicum soil implant inoculant was applied in the seed furrow at planting. The field was cultivated on June 24. Orthene at 1 lb ai/ac was sprayed on July 20 and August 3 for control of lygus bugs and stink bugs. The field was furrow irrigated as necessary.

Eighteen new selections (Table 2) from R. Cooper, USDA in Wooster, Ohio, and 26 cultivars, seed saved from 1992, research, (Table 1) were planted in plots four rows wide by 25 feet long. Seed from 241 single plant selections made from 5 cultivars in 1992 was planted in plots one or two rows wide and 25 or 15 feet long. In addition, 18 F_2 lines were grown in 1993 from crosses of Ontario lines with Ohio lines made by Richard Cooper at USDA, Wooster, Ohio, and single plants were selected (Table 3).

On July 15, at the full bloom stage, a representative sample of fully expanded leaves was collected and analyzed for nutrient levels. The results showed inadequate levels of nitrogen (Small and Ohlrogge, 1973). Urea at 15 lbs N/acre was water run on August 13.

Plant height and reproductive stage were measured every week for each cultivar. Prior to harvest the cultivars were evaluated for lodging and shatter. The middle two rows in each four-row plot and all rows from the single plant selection plots, were harvested on October 10 using a Wintersteiger Nurserymaster small plot combine. The beans were cleaned, weighed, and oven dried for moisture content determination. Dry bean yields were corrected to 13 percent moisture. Single plant selections were cut at ground level, threshed in the small plot combine and labeled individually.

Results and Discussion

The 1993 growing season was cooler than the previous six-year average with 22 percent fewer growing degree days (50-86 °F) accumulating May through September. Plant maturation was delayed and yields may have been depressed due to the cool weather. The plants were in general shorter and there was less shatter than in previous years. Lodging was also more of a problem in 1993 probably due to the higher seeding rate.

Yields for the cultivars ranged from 61 to 16 bu/ac and seed counts ranged from 3,400 to 2,200 seeds/lb (Table 1). The two highest yielding lines, Agassiz and Lambert also had little or no lodging and no shatter. Gnome 85 and OR6 also yielded well with little lodging and no shatter. Sibley, OR8, and Parker lodged heavily and never matured. Most of the other lines lodged heavily under the higher seeding rate.

Yields for the new selections from Ohio ranged from 50 to 16 bu/ac and seed counts ranged from 3,300 to 1,900 seeds/lb. In general, the new selections lodged heavily and many took too long to mature (Table 2).

As the crosses from Ohio were planted a week later than the other cultivars, none of them were mature by the end of September and so could not be evaluated for days to maturity. The crosses performed well in general with little lodging and no shatter (Table 3).

Each of the mother lines, from which single plant selections were made in 1992, yielded promising lines at the high population density in 1993 (Table 4). Several lines were identified with yields in the 60-80 bu/ac range, with little lodging and shatter, and maturity 94 to 115 days from emergence. The yields for these lines may not be representative (may be actually higher or lower) of actual production conditions, because of the lack of border rows between the lines in this trial. The promising lines will be planted and evaluated in four row plots in 1994.

Literature cited

Small, H.G. and H.A. Ohlrogge, 1973. Plant analysis as an aid in fertilizing soybean and peanut. In: Soil Testing and Plant Analysis. L.M. Walsh and J.D. Beaton (Eds.) pp. 315-328. Soil Science Society of America, Madison, WI.

Table 1. Performance characteristics of soybean cultivars as ranked by yield. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Cultivar	Days to maturity*	Lodging	Shatter	Height	Yield	Seed count
		0-10[1]	%	cm	bu/ac	seeds/lb
Agassiz	102	0	0	90	60.9	2,804
Lambert	115	2	0	100	60.8	2,385
Sibley	na	6	0	110	54.7	2,228
Gnome 85	108	0	0	103	53.2	2,563
OR-8	na	6	0	100	52.6	2,450
OR-6	102	0	0	90	51.7	2,606
Parker	122	8	0	140	51.4	2,283
Evans	115	2	0	100	50.9	2,597
HC89-2018	115	2	0	100	49.7	2,652
NS92-12	na	10	0	95	38.0	2,769
HC-8756	na	4	0	95	37.0	3,123
HC-8759	na	8	0	90	34.3	3,422
HC88-3157	na	6	0	90	34.0	2,762
NS92-5	na	8	0	90	33.8	2,840
Hoyt	122	8	0	90	33.3	2,990
NS92-13	na	6	0	80	32.8	2,560
NS91-37	122	6	0	80	30.1	3,162
NS92-18	na	2	0	95	29.8	2,823
NS91-13	122	2	0	95	28.9	2,736
NS91-56	na	8	0	85	26.8	2,994
NS92-4	na	8	0	85	25.5	3,260
NS92-15	na	8	0	105	24.6	2,612
NS91-40	122	8	0	75	24.3	3,121
NS92-3	na	8	0	100	17.0	2,736
NS92-20	na	10	0	90	15.6	2,861
NS92-19	na	8	0	90	15.5	2,634
LSD(0.05)					8.7	173

* from emergence

1 0= none, 10= 100 % lodging

na; data not available since it failed to mature

Table 2. Performance characteristics of soybean new selections introduced from USDA, Wooster, Ohio as ranked by yield. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Selection	Days to maturity*	Lodging	Shatter	Height	Yield	Seed count
		0-10⁺	%	cm	bu/ac	seeds/lb
663	115	8	0	100	50.35	2,732
1586	na	2	0	90	50.31	2,577
1923	115	4	0	90	42.81	2,674
1495	na	4	0	70	41.35	2,242
1305	121	6	0	90	41.34	2,564
1265	122	8	0	85	39.66	2,994
1920	122	0	0	85	37.27	2,959
1302	na	2	0	90	36.75	2,525
1001	122	2	0	90	35.95	2,273
1926	na	6	0	90	33.50	2,809
1424	123	2	0	80	33.33	2,066
1321	123	6	0	85	33.15	2,591
2663	122	2	0	90	27.71	1,916
1427	na	2	0	75	25.33	2,415
2675	122	8	0	95	24.20	3,333
1425	na	8	0	85	22.84	2,174
665	115	10	0	105	19.50	3,145
1423	122	10	0	90	16.15	3,086

* from emergence
\+ 0 = none, 10 = 100%
na; data not available since it failed to mature

Table 3. Performance characteristics of soybean crosses introduced from USDA, Wooster, Ohio. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

F_2 Plant #	Cross	Lodging	Shatter	Height
		0-10*	%	cm
18-1	Charleston BC X OR8	0	0	95
18-2	Charleston BC X OR8	0	0	105
18-3	Charleston BC X OR8	0	0	100
18-4	Charleston BC X OR8	0	0	105
18-5	Charleston BC X OR8	0	0	105
18-6	Charleston BC X OR8	0	0	90
19-1	Charleston BC X H16-3	0	0	85
19-2	Charleston BC X H16-3	2	0	90
19-3	Charleston BC X H16-3	0	0	85
19-4	Charleston BC X H16-3	0	0	105
20-1	Charleston BC X H16-7	4	0	70
20-2	Charleston BC X H16-7	0	0	80
21-1	Charleston BC X H82-14	0	0	80
21-2	Charleston BC X H82-14	6	0	105
21-3	Charleston BC X H82-14	0	0	75
21-4	Charleston BC X H82-14	0	0	75
22	Sprite 87 X OR6	4	0	100
23	H16-3 X H78-676-3	0	0	95

* 0 = none, 10 = 100%

Table 4. Summary of performance characteristics of 241 single plant selections made in 1992 from soybean F_5 lines originally bred and selected for eastern Oregon adaptation. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Mother line	# of selections	Range of days to maturity*	Height range	Seed size range	Yield range
			cm	seeds/lb	bu/ac
H16-12	106	94-122	58-105	2,100-3,500	19-130
H16-3	50	94-102	48-100	2,100-3,200	22-61
H16-7	54	94-122	60-103	2,100-3,400	14-69
H4-6	12	94-122	80-105	2,500-3,200	25-70
H82-14	19	94-122	87-100	2,400-3,000	39-63

* from emergence

VEGETABLE SOYBEAN (EDAMAME) PERFORMANCE AT ONTARIO IN 1993

Erik Feibert, Clint Shock and Monty Saunders
Malheur Experiment Station
Oregon State University
Ontario, Oregon

Introduction

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

Procedures

The 1993 trial was conducted on a silt loam previously planted to spring wheat. The field was moldboard plowed in the fall of 1992 and groundhogged and bedded in the spring of 1993. Dual at 2 lbs ai/ac was sprayed and incorporated with a bed harrow on May 21. Seed of the nine cultivars was planted on May 22 at 120,000 seeds/acre in rows 22 inches apart. Rhizobium japonicum soil implant inoculant was applied in the seed furrow at planting. The field was cultivated on June 24. Orthene at 1 lb ai/ac was sprayed on July 20 and August 3 for control of lygus and stink bugs. The field was furrow irrigated as necessary. Plots were four rows wide and arranged in a randomized complete block design with five replicates.

On July 15, at the full bloom stage, a representative sample of fully expanded leaves was collected and analyzed for nutrient levels. The results showed inadequate levels of nitrogen (Small and Ohlrogge, 1973). Urea at 15 lbs N/acre was water run on August 13.

Plant height and reproductive stage were measured every week for each cultivar. When a cultivar reached the R6 stage, bean samples from the border rows were dried in a microwave oven for 30 minutes at medium for determination of moisture content. Three feet of the middle two rows in each plot were harvested when the bean moisture content for a variety reached 70 percent. Plants were cut at ground level and measured for total weight and pod weight. A subsample of pods was weighed, shelled, and the beans were weighed and oven dried for moisture content determination. A sample of beans at the dry bean stage was taken for determination of seed weight. Seed weight was corrected to 13 percent moisture.

Results and Discussion

The 1993 growing season was cooler than the previous six-year average with 22 percent fewer growing degree days (50-86 °F) accumulating May through September. Plant maturation was delayed and yields may have been depressed due to the cool weather.

Vegetable soybeans for export to Japan must have a seed count of 1,512 seeds/lb or less, and pods must have white pubescence. Beans must have a characteristic taste that is sweeter and less beany than conventional soybeans. In addition, the plants should be about 18-24 inches (45-60 cm) tall to facilitate mechanical harvesting.

The cultivars were in general of shorter stature and consequently did not lodge compared to the grain soybean cultivars grown along side. All cultivars except Kitanosuzu had large enough seeds to be of export quality. Sapporo-Midori, Hokuei, and Thoya cultivars were short enough for efficient mechanical harvest. Yusuzumi took substantially longer than the other cultivars to reach the green bean harvest stage. All cultivars reached the dry bean maturity stage (R7) soon after the green bean stage (R6). Pods of all cultivars shattered intensely at the R7 stage.

Literature cited

Small, H.G. and H.A. Ohlrogge, 1973. Plant analysis as an aid in fertilizing soybean and peanut. In: Soil Testing and Plant Analysis. L.M. Walsh and J.D. Beaton (Eds.) pp. 315-328. Soil Science Society of America, Madison, WI.

Table 1. Characteristics of nine vegetable soybean cultivars (edamame). Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Cultivar	Source	Height	Days to green bean harvest*	Green bean stage					Dry bean stage		
				Plant top yield	Pod yield	Bean/pod ratio	Pod pubescence color	Green bean moisture	Lodging	Shatter	Seed count
		cm		— lb/ac —		g/g		%	0-10[1]	%	seeds/lb
Kitanosuzu	4	65	96	28,942	13,880	0.58	white	66	0	100	1,779
Sayamusume	4	80	103	40,179	18,406	0.53	white	71	0	100	1,366
Sapporo-Midori	4	40	96	27,657	11,865	0.59	white	71	0	100	1,314
Oharu	2	80	103	39,618	16,627	0.51	white	71	0	100	1,451
Hokuei	2	43	96	25,449	10,543	0.58	tan	57	0	100	1,330
Thoya	3	45	96	25,693	10,801	0.64	white	70	0	100	1,316
Karikachi	3	90	103	40,821	18,901	0.54	white	70	0	100	1,487
Yusuzumi	1	68	115	26,284	8,749	0.42	white	70	0	100	1,360
Shirofumi	1	70	98	na	14,471	0.44	white	73	0	100	1,386
LSD(0.05)				4,985	2,636	0.048		ns			98

* from emergence, 1 0 = no lodging, 10 = 100 % lodging, na: data not available

<u>Seed sources:</u>
1 = Sakata Seed America Inc., Morgan Hill, Ca
2 = Kyowa Seed Co., Ltd., Tokyo, Japan
3 = Tokita Seed Co., Ltd., Saitama-Ken, Japan
4 = East - West Seeds, Olympia, WA

SUGAR BEET VARIETY TESTING RESULTS, 1993

Charles E. Stanger and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Purpose

Commercial varieties and experimental lines of sugar beets were evaluated to identify lines with high sugar yields and root quality. A joint seed advisory committee evaluates the accumulated performance data for the varieties, and restricts growers in Idaho and Malheur County of Oregon to planting only those varieties ranking above minimum industry requirements.

Procedures

Eighteen commercial and 35 experimental lines of sugar beets were evaluated in two trials conducted by Oregon State University at the Malheur Experiment Station. Seed for evaluation was received from American Crystal, Betaseed, Hilleshog Mono-Hy Inc., Holly, Spreckels, and Seedex beet seed companies. The sugar beets were planted in Owyhee silt loam soil where wheat or field corn was planted the previous year. Soil pH was 7.3 at the experiment station and 6.9 at the Wettstein farm. The soil organic matter was 1.2 percent. The fields were plowed in the fall of 1991. One hundred pounds of phosphate and 60 lb of N were applied as a broadcast treatment before plowing. An additional 150 lb of nitrogen was added by sidedressing ammonium sulfate after thinning. Two lb ai/ac of Nortron was broadcast for weed control and incorporated using a spike-tooth bed harrow before planting.

The commercial varieties and experimental lines were planted in separate trials. Each entry was replicated eight times and arranged in a complete randomized block experimental design. Each plot was four rows wide and 23 feet long with four-foot allies separating each plot. Approximately 12 viable seeds per foot of row were planted. The seed was planted on April 26, 27, and 28 with a cone-seeder mounted on a John Deere model 71 flexi-planter equipped with disc openers. After planting, the sugar beets were corrugated and surface-irrigated to assure moisture for uniform seed germination and seedling emergence.

The sugar beets were hand-thinned during the third week of May. Spacing between plants was approximately 7 inches. In mid-July, and again on August 10, 80 lbs/ac powdered sulfur was spread by aerial application over the foliage to protect the sugar beet leaves from powdery mildew infection.

The sugar beets were harvested during the 2nd and 3rd weeks of October. The foliage was removed by a flail beater and the crowns clipped with rotating scalping knives. The roots from the two center rows of each four-row plot were dug with a single-row wheel-type lifter harvester, and all roots in each 23 feet of row were weighed to calculate root yields. A sample of eight beets was taken from each of the harvested rows and analyzed for percent sucrose, nitrate, and conductivity. The percent extraction was calculated using percent sucrose, root nitrate, and conductivity.

Results

Variety performance has been grouped by seed company (Table 1, 2, 3, and 4). Each variety was ranked within each company's group by yield of recoverable sugar per acre. The data was analyzed statistically for LSD value at the 5 percent level of significance, coefficient of variation, and means for all evaluated parameters.

Yields of recoverable sugar from experimental varieties ranged from a high of 7.370 tons of sugar/ac to a low of 5.775 tons of sugar/ac, with a variety mean of 6.665 tons of sugar/ac at the experiment station. Yields were lower at the Wettstein farm.

Yield of recoverable sugar from commercial lines ranged from 7.485 tons of sugar/ac to a low of 6.125 tons of sugar/ac, with an entry mean of 6.855 tons of sugar/ac at the experiment station. Again yields at the Wettstein farm were slightly lower.

Table 1. Results of sugar beet commercial varieties entered in testing trials conducted at the Wettstein farm by Oregon State University, Malheur Experiment Station, Ontario, Oregon, 1993.

Company	Entry	Root yield	Sucrose	NO_3 -N	Conductivity	Extraction	Recoverable sugar	Curly-top ratings[1]
		ac	%	ppm	mmhos	%	lbs/ac	
American Crystal	ACH-203	40.76	17.50	169	604	86.98	12,420	4.4
	ACH-199	40.43	17.45	165	646	86.43	12,200	4.3
	ACH-200	38.74	17.32	136	565	87.45	11,730	3.8
	ACH-177	35.75	18.49	80	544	87.93	11,630	4.7
Betaseed	8450	43.16	17.00	175	676	85.95	12,620	4.0
	8422	39.85	18.08	124	592	87.25	12,570	4.1
	8251	40.69	17.00	154	635	86.48	11,970	4.1
Hilleshog Mono-Hy	WS-62	42.77	17.06	136	572	87.31	12,740	3.8
	WS-870	42.77	16.92	126	564	87.39	12,660	3.6
	WS-PM9	42.25	16.94	119	577	87.23	12,480	3.9
	WS-41	40.56	17.33	98	555	87.58	12,320	4.4
	WS-88	40.37	17.33	110	574	87.34	12,210	3.5
	HM-R2	41.73	16.85	108	627	86.57	12,170	4.4
	WS-91	40.04	17.24	144	593	87.08	12,020	3.3
	HM2912	39.19	16.74	121	609	86.77	11,390	3.8
	HM WS-21	36.33	17.06	120	569	87.35	10,830	4.2
	HM RH-2	35.03	17.01	96	565	87.39	10,420	4.1
Mean		40.04	17.29	128	593	87.08	12,050	
LSD (0.05)		1.42	0.397	42	47	0.656	547	
CV (%)		3.59	2.32	33.0	8.01	.760	4.59	

[1] Curly-top standards are the resistant variety US 41 = 4.2 and the susceptible variety US 33 = 4.4.

Table 2. Results of sugar beet commercial varieties entered in testing trials conducted at the Malheur Experiment Station, Ontario, Oregon, 1993. Station location.

Company	Entry	Root yield	Sucrose	NO_3 -N	Conductivity	Extraction	Recoverable sugar	Curly-top ratings[1]
		tons/ac	%	ppm	mmhos	%	%	
American Crystal	ACH-203	45.11	17.86	123	592	87.29	14,030	4.4
	ACH-177	40.43	18.45	134	595	87.36	13,000	4.7
	ACH-200	41.92	17.73	118	579	87.45	12,970	3.8
	ACH-199	42.51	17.52	122	640	86.63	12,880	4.3
Betaseed	8450	45.43	17.40	142	680	86.08	13,600	4.0
	8422	44.00	17.70	128	623	86.87	13,510	4.1
	8251	42.77	17.24	126	632	86.67	12,770	4.1
Hilleshog Mono-Hy	WS-62	48.10	17.30	120	578	87.38	14,520	3.8
	WS-870	46.60	17.54	97	534	87.99	14,360	3.6
	WS-PM9	47.32	17.08	135	573	87.39	14,100	3.9
	WS-91	44.27	17.60	129	604	87.11	13,560	3.3
	WS-41	44.07	17.33	150	611	86.97	13,270	4.4
	HM-R2	44.78	17.03	120	638	86.56	13,170	4.4
	WS-88	43.09	17.46	109	596	87.18	13,110	3.5
	HM-2912	42.70	17.38	89	600	87.12	12,920	3.8
	HMWS-21	39.97	17.33	117	613	86.93	12,020	4.2
	HM-RH2	40.23	16.96	139	591	87.14	11,860	4.2
Mean		43.67	17.50	122	605	87.07	13,280	
LSD (0.05)		1.48	0.315	42	44	0.614	466	
CV (%)		3.43	1.819	34	7.41	0.712	3.55	

[1] Curly-top standards are the resistant variety US 41 = 4.2 and the susceptible variety US 33 = 4.4.

Table 3. Results of sugar beet experimental varieties entered in testing trials conducted at Oregon State University, Malheur Experiment Station, Ontario, Oregon, 1993.

Company	Entry	Root yields	Sucrose	NO_3 -N	Conductivity	Extraction	Recoverable Sugar	Curly-top ratings[1]
		ac	%	ppm	mmhos	%	%	
American Crystal	ACH-203	44.78	17.50	97	584	87.25	13,670	4.4
	9250385	43.74	17.72	85	553	87.68	13,590	4.0
	9250332	44.91	17.37	69	618	86.78	13,550	3.9
Betaseed	2BG 6305	44.78	18.44	83	614	87.02	14,370	4.1
	1BG 6458	47.45	17.15	74	626	86.63	14,110	3.4
	OBG 6025	46.67	17.39	98	642	86.48	14,040	4.4
	OBG 6954	47.32	17.06	71	615	86.76	14,010	3.7
	OBG 6953	46.28	17.17	82	627	86.60	13,770	3.3
	1BX 8423	43.68	17.83	78	596	87.16	13,530	3.7
	8450	45.56	17.12	101	664	86.14	13,430	4.0
	1BG 6517	41.73	17.44	69	574	87.36	12,720	3.5
	1BG 6466	41.15	17.60	66	568	87.47	12,670	3.7
	2BG 6205	43.22	17.11	119	706	85.60	12,650	3.6
	4581	44.20	16.59	147	769	84.67	12,430	4.4
	1BG 6474	41.67	17.12	108	689	85.80	12,250	3.8
	1BG 6470	44.26	16.06	81	693	85.40	12,220	3.5
Hilleshog Mono-Hy	HM2916	47.56	17.69	72	561	87.57	14,740	3.2
	HM2915	48.68	17.32	97	592	87.10	14,700	3.4
	WS-870	47.77	17.33	80	531	87.89	14,560	3.6
	WS-PM9	47.90	17.27	84	541	87.75	14,520	3.5
	HMWS-8174	48.16	17.11	88	588	87.13	14,350	3.6
	HM 9155	47.84	17.21	90	606	86.90	14,310	4.1
	HM 2917	44.85	17.70	83	552	87.68	13,930	4.4
Holly	93 HX29	44.07	17.03	117	671	86.03	12,910	4.8
	Rhizosen	44.40	16.95	113	697	85.68	12,900	4.3
	93 HX18	44.78	16.72	98	671	85.98	12,880	4.3
	Rhizosen CT	43.49	16.87	89	619	86.66	12,720	4.4
	Rhizoguard	43.16	17.05	82	673	86.01	12,660	4.4
	Rhizoguard CT	42.90	16.57	90	641	86.32	12,280	4.0
	Rhizosen PLUS	39.32	16.93	91	614	86.75	11,550	4.4
Seedex	SX 1502	45.17	17.24	65	608	86.9	13,530	3.8
	SX 1501	40.56	18.58	79	622	86.94	13,110	4.1
	SX 1503	45.69	16.46	91	654	86.13	12,960	4.3
Spreckels	SS-780R	44.46	16.60	93	691	85.68	12,650	4.1
	SS-287R	43.16	16.56	94	641	86.33	12,360	3.8
Mean		44.72	17.20	89	626	86.64	13,330	
LSD (0.05)		1.90	0.617	28	33	0.484	814	
CV (%)		4.31	3.64	32	5.32	0.568	6.20	

[1] Curly-top standards are the resistant variety US 41 = 4.2 and the susceptible variety US 33 = 4.4.

Table 4. Results of sugar beet experimental varieties entered in testing trials conducted at the Wettstein farm by Oregon State University, Malheur Experiment Station, Ontario, Oregon, 1993.

Company	Entry	Root yield	Sucrose	NO_3 -N	Conductivity	Extraction	Recoverable Sugar	Curly-top ratings[1]
		ac	%	ppm		%	%	
American Crystal	9250385	39.91	18.15	93	551	87.78	12,720	4.0
	ACH-203	39.85	18.06	104	565	87.58	12,610	4.4
	9250332	38.35	17.08	99	604	86.90	11,380	3.9
Betaseed	OBG6025	40.76	17.88	116	589	87.25	12,720	4.4
	1BX8423	39.46	18.34	94.4	579	87.46	12,650	3.7
	8450	40.82	17.34	132	651	86.35	12,220	4.0
	2BG6305	37.44	18.40	79	576	87.50	12,040	4.1
	2BG6205	39.19	17.61	111	635	86.61	11,950	3.6
	OBG6953	39.78	17.17	88	589	87.12	11,900	3.3
	1BG6458	40.76	17.01	136	687	85.81	11,880	3.4
	OBG6954	40.24	16.92	110	628	86.57	11,780	3.7
	4581	40.63	16.81	178	663	86.08	11,750	4.4
	1BG6474	37.57	17.57	86	612	86.90	11,470	3.8
	1BG6470	38.35	17.12	89	648	86.34	11,340	3.5
	1BG6517	34.65	17.70	90	570	87.46	10,720	3.5
	1BG6466	33.60	17.52	79	550	87.62	10,320	3.7
Hilleshog Mono-Hy	HM2916	41.08	18.08	106	533	88.00	13,070	3.2
	HM2917	41.15	18.05	106	541	87.89	13,050	4.4
	HM2915	42.58	17.53	132	598	87.05	12,990	3.4
	HM9155	43.10	17.33	113	618	86.78	12,960	4.1
	WS-PM9	41.08	17.19	81	523	87.95	12,410	3.5
	WS-870	40.89	17.20	104	560	87.49	12,290	3.6
	HMWS-8174	40.76	17.20	93	571	87.35	12,250	3.6
Holly	Rhizosen CT	40.3	16.89	115	573	87.26	11,870	4.4
	93 HX18	39.85	17.13	96	624	86.65	11,830	4.3
	Rhizosen	40.3	16.94	141	626	86.60	11,820	4.3
	93 HX 29	38.55	17.58	117	594	87.14	11,810	4.8
	Rhizoguard CT	39.39	16.81	121	603	86.86	11,500	4.0
	Rhizoguard	38.03	16.88	109	598	86.94	11,160	4.4
	Rhizosen PLUS	33.60	17.20	121	581	87.22	10,070	4.4
Seedex	SX 1501	36.33	18.82	98	605	87.21	11,930	4.1
	SX 1503	39.65	16.42	116	657	86.09	11,210	4.3
	SX 1502	36.72	17.22	74	577	87.28	11,040	3.8
Spreckels	SS-780R	38.02	17.31	86	599	87.02	11,460	4.1
	SS-287R	38.16	16.80	104	614	86.72	11,130	3.8
Mean		39.17	17.41	106	597	87.05	11,870	
LSD (0.05)		1.691	0.354	39	55	0.747	513	
CV(%)		4.38	2.07	37	9.3	0.871	4.39	

[1] Curly-top standards are the resistant variety US 41 = 4.2 and the susceptible variety US 33 = 4.4.

HERBICIDE TRIALS TO EVALUATE FOLIAR AND SOIL ACTIVE HERBICIDES FOR CROP TOLERANCE AND WEED CONTROL IN SUGAR BEETS

Charles E. Stanger and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Purpose

Trials were conducted to evaluate herbicides for weed control and crop tolerance when applied as postemergence and laybye applications. Postemergence herbicides included Betamix, Stinger, Nortron, Poast, Upbeet, NA-305, NA-307, NA-308, and CQ-145. Each herbicide was evaluated in two and three way tank-mixes applied at various rates. Laybye herbicides were applied when sugar beets had six leaves. All laybye herbicides were soil incorporated with sinner weeders during cultivation. Herbicides applied as laybye treatments included Roneet, Prowl, Sonalan, and Dual. Application of the postemergence treatments were begun when the weeds in the sugar beets were at the cotyledon stage. Repeat applications followed as new weeds emerged. The purpose of this study was to identify herbicides, rates, and timing of applications that allow full season weed control by herbicides and thereby eliminate hand-weeding.

Procedure

Raw seed of MonoHy PM-9 sugar beets was planted on April 27 and furrow irrigated on April 28. Soils were silt loam texture, with a pH of 7.3 and 1.3 percent organic matter. The 1992 crop was Stephens wheat. The applications of the postemergence treatments were begun on May 18. Sequential applications followed on June 4 and June 11. On May 18 the sugar beets had small cotyledon leaves. The grass species had two true leaves. The herbicide spray was applied using a single bicycle wheel plot sprayer equipped with a 7.5 foot boom with four teejet fan nozzles, size 8002, spaced 22 inches apart so a single nozzle was centered over each row of the four row plots. Spray pressure was 42 psi and water was applied at a spray volume of 19.5 gal/ac. Herbicide treatments and listed in Tables 1, 2, 3, and 4.

The laybye herbicides were applied on June 11 to six-leaf sugar beets. The sugar beets were weed free following three sequential applications of a herbicide tank-mix containing Betamix, Stinger, and Poast. The laybye herbicides were applied as broadcast applications and incorporated with sinner weeders mounted on a rear cultivating bar. Sinner weeders were used after laybye herbicides were applied during normal cultivations until the crop was layed-bye. Herbicides and rates included Roneet (4 lb ai/ac), Prowl (1.0, 1.5 and 2.0 lb ai/ac), Dual (2 and 4 lb ai/ac), and Sonalan (1.0 and 1.5 lb ai/ac). Individual plots were 8 rows wide and 50 feet long. Each treatment was replicated three times using a randomized complete block experimental design.

Dupont's Upbeet postemergence treatments and beets receiving laybye treatments were harvested for root yield and quality. Sugar beets from the two center rows of each of the four row plots were harvested to determine root tonnage. Two eight-beet samples were taken from each row to analyze for root quality. All root samples for quality analysis (percent sucrose, conductivity, root NO_3N) were analyzed at the Nyssa Sugar Factory tare lab facility.

Results

Weed species were redroot pigweed, hairy nightshade, lambsquarters, sow thistle, and barnyardgrass. Poast herbicide for grass control was compatible in tank-mixes with all broadleaf herbicides evaluated in these trials. Poast at 0.1 lb ai/ac applied twice in tank-mixes with broadleaf herbicides controlled all barnyardgrass plants. Grass was not effectively controlled except when Poast was added in tank-mixes with the broadleaf herbicides. All broadleaf weed species were effectively controlled only when two or more broadleaf herbicides were tank-mixed. Upbeet did have partial activity on each weed species, and when Upbeet was tank-mixed with other herbicides including Betamix, Nortron, NA-308, or Stinger, good weed control was obtained. Full weed control was obtained from three sequential applications of the Nor-Am mixtures including NA-305, 307, 308, and CQ-145. Each of these materials contain a mixture of Betanal + Betanex + Nortron SC at a ratio of 1:1:1. Seedling sugar beets were very tolerant of these numbered materials when the first application rate was 0.25 lbs ai/ac followed by two sequential applications at 0.33 lbs ai/ac. Sugar beets were less tolerant to higher rates. Betamix + Nortron combination at 0.25 + 0.25 lbs ai/ac caused some leaf burn and stunting of seedling sugar beet growth. These higher rates were not necessary for weed control. Upbeet and Stinger were both compatible with the Nor-Am numbered materials, and could be used as tank-mixes for improved control of kochia, hairy nightshade, and other species of weeds in the composite and legume family (Tables 1, 2 and 3).

Severe injury to seedling sugar beets did occur when MorAct crop oil concentrate and Dash were tank-mixed with Poast and Betamix herbicides. Additional surface acting agents should not be added when Betamix is used in a tank-mix (Table 4).

Upbeet or Upbeet tank-mixes did not reduce root yields, percent sucrose, or sugar yields when applied three times as sequential applications to seedling sugar beets. In untreated check plots, weeds left growing with the seedling sugar beets until removed by hand-weeding did reduce both root and sugar yields. In some cases the yield difference between the untreated checks and herbicide-treated sugar beets were significant at the five percent level (Table 5). Percent sucrose for the check treatments was higher than for some herbicide treatments, but usually not enough difference to be considered statistically significant.

Prowl herbicides at 1.5 and 2.0 lbs ai/ac rates applied to six-leaf sugar beets as laybye treatments caused enough sugar beets injury to significantly reduce root yields, percent sucrose, and recoverable sugar. Prowl at 1.0 lb ai/ac also reduced yield compared to the check and other herbicide treatments, but ot enough to be significant. Sonalan at 1.5 ai/ac reduced percent sucrose. Sugar beets were most tolerant to Dual at both rates and had adequate tolerance to Roneet at 4 lbs ai/ac (Table 6).

Table 1. Percent weed control and crop injury ratings from herbicide treatments applied to seedling sugar beets as sequential postemergence applications. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

			Percent weed control																							
			Crop Injury				Pigweed				H. Nightshade				Lambsquarters				Sow Thistle				Barnyardgrass			
	Rate & application[1]		1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A
Herbicide	lbs ai/ac	No.	---- % ----				---- % ----																			
Upbeet + Betamix	0.0156 + 0.33	2	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	96	98	98	97
Upbeet + Betamix	0.0156 + 0.33	3	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + Betamix	0.0156 + 0.25	2	0	0	0	0	99	99	100	99	100	100	100	100	100	100	100	100	100	100	100	100	94	95	98	95
Upbeet + Betamix	0.0156 + 0.25	3	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + X-77	0.0156 + 0.25%	2	0	0	0	0	82	85	80	82	85	80	80	82	82	85	80	82	35	45	35	38	92	90	85	88
Upbeet + X-77	0.0156 + 0.25%	3	0	0	0	0	95	85	75	85	95	80	70	71	90	80	70	80	40	45	40	42	95	90	70	81
Betamix	0.33	2	0	0	0	0	99	99	96	98	98	98	96	97	100	100	100	100	100	100	100	100	98	98	95	96
Betamix	0.33	3	0	0	0	0	99	100	100	99	100	100	100	100	100	100	100	100	100	100	100	100	99	100	100	99
Betamix + Stinger + Nortron	0.25 + 0.05 + 0.25	2	45	35	30	36	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Stinger + Nortron	0.25 + 0.05 + 0.25	3	15	30	30	25	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Upbeet + Stinger	0.25 + 0.15 + 0.05	2	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Upbeet + Stinger	0.25 + 0.15 + 0.05	3	5	0	0	2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Upbeet + Nortron	0.25 + 0.0156 + 0.25	2	5	0	5	3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Upbeet + Nortron	0.25 + 0.0156 + 0.25	3	5	0	0	2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Nortron	0.25 + 0.25	2	0	10	0	3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Nortron	0.25 + 0.25	3	20	15	20	18	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Stinger	0.33 + 0.25	2	0	0	0	0	99	96	93	96	100	100	100	100	100	100	100	100	100	100	100	100	99	99	95	98
Betamix + Stinger	0.33 + 0.25	3	0	0	0	0	99	100	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + Stinger	0.0156 + 0.05	2	0	0	0	0	80	80	80	80	98	98	98	98	80	80	80	80	100	100	100	100	80	80	75	78
Upbeet + Stinger	0.0156 + 0.05	3	0	0	0	0	75	75	80	77	95	95	98	96	80	80	80	80	100	100	100	100	75	80	85	80
Betamix + Nortron + Dual	0.25 + 0.25 + 4	3	10	10	5	8	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Stinger + Dual	0.33 + 0.05 + 4	3	5	10	5	7	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Upbeet + Dual	0.33 + 0.0156 + 4	3	5	0	0	2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Check	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

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[1] Poast herbicide added to all treatments after the first application at 0.1 lb ai/ac for grass control.
Rating: 0 = no control, 100 = all weeds killed.

Table 2. Percent weed control and crop injury ratings for NorAm herbicide treatments applied as postemergence sequential applications to seedling sugar beets. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Applications[1]		Percent weed control																								
			Crop Injury				Pigweed				H. nightshade				Lambsquarters				Sow thistle				Barnyardgrass			
	Rate 1	Rate 2 and 3	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A
Herbicide	----- lb ai/ac -----		---- % ----				%																			
Betamix	0.25	0.33	0	0	0	0	99	98	98	98	100	98	95	97	100	98	98	98	100	100	100	100	99	96	94	96
Betamix	0.375	0.5	0	5	5	3	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
NA 305/2	0.25	.33	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
NA 305/2	0.375	0.5	10	5	5	7	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
NA 307/2	0.25	0.33	5	0	0	2	100	99	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
NA 307/2	0.375	0.5	10	5	10	8	99	100	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
NA 308/1	0.25	0.33	0	0	0	0	100	100	100	100	99	99	99	99	100	100	100	100	100	100	100	100	100	100	100	100
NA 308/1	0.375	0.5	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
CQ 1451/2	0.25	0.33	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
CQ 1451/2	0.375	0.5	10	10	5	8	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Nortron	0.167 + 0.083	0.22 + 0.1	0	0	0	0	99	100	100	99	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix + Nortron	0.25 + 0.8125	0.33 + 0.165	0	5	0	2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
NA 308/1	0.193	0.193	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
NA 308/1	0.292	0.292	5	0	0	2	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Betamix	-	0.75	10	10	0	7	65	65	50	60	70	40	50	53	75	50	50	59	65	65	50	55	70	50	45	55
Betamix + Nortron	-	0.5 + 0.25	0	0	0	0	65	65	65	65	60	60	60	60	75	65	65	68	60	55	60	58	70	70	65	68
NA 308/1 + Stinger	0.25 + 0.093	0.33 + 0.093	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
NA 308/1 + Upbeet	0.25 + 0.0156	0.33 + 0.0156	0	0	0	0	100	100	100	100	100	100	100	100	100	100	99	99	100	100	100	100	100	100	100	100
NA 308/1 + Upbeet	0.25 + 0.0117	0.33 + 0.0117	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Check	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Poast herbicide added to all treatments after the first application at 0.1 lb ai/ac for grass control.
Ratings: 0 = no control, 100 = all weeds killed

Table 3. Percent weed control and crop injury ratings for Dupont herbicide treatments applied as postemergence sequential applications to seedling sugar beets. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Application[1]						Percent weed control																			
			% Crop injury				Pigweed				H. nightshade				Lambsquarters				Sow thistle				Barnyardgrass			
	Rate 1	Rate 2 and 3	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A
Herbicide	···· lb ai/ac ····						································ % ································																			
Upbeet + X-77	0.0156	0.0156	0	0	0	0	75	70	70	72	75	70	70	72	35	30	30	32	10	15	20	15	100	100	100	100
Betamix	0.25	0.33	0	0	0	0	95	98	95	96	95	98	95	96	100	100	100	100	100	100	100	100	100	100	100	100
NA 308	0.25	0.33	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
NA 308	0.375	0.50	5	5	5	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + Betamix	0.0156 + 0.1875	0.0156 + 0.25	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + Betamix	0.0156 + 0.25	0.0156 + 0.33	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + Betamix	0.0156 + 0.33	0.0156 + 0.33	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + Betamix	0.01175 + 0.25	0.01175 + 0.33	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + NA 308	0.0156 + 0.25	0.0156 + 0.33	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + NA 308	0.0156 + 0.375	0.0156 + 0.375	5	5	5	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + NA 308	0.0156 + 0.375	0.0156 + 0.50	10	10	10	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + NA 308	0.01175 + 0.25	0.01175 + 0.33	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + NA 308	0.01175 + 0.375	0.01175 + 0.5	10	10	10	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + Stinger + NA 308	0.0156 + 0.05 + 0.25	fB	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + Betamix + Nortron	0.0156 + 0.25 + 0.25	fB	25	30	25	26	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Upbeet + Betamix + Nortron + Stinger	0.0156 + 0.25 + 0.25 + 0.05	fB	25	25	30	26	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Check	---		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

fB = sequential applications applied at the same rate.

[1] Poast herbicide added to all treatments after the first application at rate of 0.1 lb ai/ac

Table 4. Percent weed control and crop injury ratings from BASF herbicide treatments with crop oil concentrates added applied as sequential postemergence applications to seedling sugar beets. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Application		Crop injury				Percent weed control																			
							Pigweed				H. nightshade				Lambsquarters				Sow thistle				Barnyardgrass			
	Rate 1	Rate 2 and 3	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A
Herbicide	lb ai/ac		----- % -----				%																			
Poast + Betamix	0.1 + 0.33	0.1 + 0.33	10	15	15	13	95	93	97	95	93	90	93	92	100	100	100	100	100	100	100	100	100	100	100	100
Poast + Betamix + COC[1]	0.1 + 0.33	0.1 + 0.33	50	60	60	57	99	97	97	97	95	95	95	95	100	100	100	100	100	100	100	100	100	100	100	100
Poast + Betamix + Dash[2]	0.1 + 0.33	0.1 + 0.33	60	50	50	53	98	95	95	96	93	95	97	95	100	100	100	100	100	100	100	100	100	100	100	100
Poast + Betamix + Stinger + COC[1]	0.1 + 0.33 + 0.05	0.1 + 0.33 + 0.5	65	50	50	55	95	95	98	96	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Check	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] COC added at rate of 1 qt/ac.
[2] Dash added at rate of 1 pt/ac

Dates of herbicide application and spraying conditions:

-May 15 Applied first application to sugar beets at the full cotyledon growth stage.
Spray time : 9-10 a.m.
Air temperature: 84°F
Soil temperature: 75° at 4" depth
Wind: calm
Soil moisture: 75%
Broadleaf weeds had 2-4 true leaves, barnyardgrass 2-3 leaves

-June 9 Sprayed second application. Sugar beet leaves previously treated with COC or Dash added to Betamix were severely burned. In most cases, leaves were burnt off.
Many weeds present at the time of this application were large from new emergence and more rapid growth than sugar beets recovering from herbicide recovery.
Air temperature: 73°F
Wind: calm
Humidity: 42%
Soil was dry at surface, wet at two inches.
Soil temperature: 72°F at 4" depth.

Table 5. Root yield, root quality, and sugar yield per acre from sugar beets treated with Dupont herbicides applied as sequential postemergence applications to seedling sugar beets. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Herbicide	Application							
	Rate 1	Rate 2 and 3	Root yield	Sucrose	NO^{3}N	Conductivity	Extraction	Sugar
	Rate	lbs ai/ac	t/ac	%	ppm	mohms	%	t/ac
Upbeet X-77	0.0156	0.0156	37.9	16.40	363	677	85.83	5.335
Betamix	0.25	0.33	37.3	16.43	358	691	85.64	5.249
NA 308	0.25	0.33	40.6	16.32	383	716	85.29	5.653
NA 308	0.375	0.5	38.3	16.66	347	686	85.75	5.476
Upbeet + Betamix	0.0156 + 0.1875	0.0156 + 0.25	39.9	16.54	381	693	85.64	5.649
Upbeet + Betamix	0.0156 + 0.25	0.0156 + 0.33	39.6	16.62	379	636	86.39	5.678
Upbeet + Betamix	0.0156 + 0.33	0.0156 + 0.33	39.4	16.48	386	685	85.74	5.563
Upbeet + Betamix	0.01175 + 0.25	0.01175 + 0.33	39.9	16.31	375	718	85.27	5.550
Upbeet - NA 308	0.0156 + 0.25	0.0156 + 0.33	39.0	16.23	424	721	85.43	5.287
Upbeet - NA 308	0.0156 + 0.375	0.0156 + 0.375	37.6	16.48	367	708	85.43	5.287
Upbeet - NA 308	0.0156 + 0.375	0.0156 + 0.50	39.8	16.53	347	708	85.45	5.624
Upbeet - NA 308	0.01175 + 0.25	0.01175 + 0.33	38.6	16.95	261	662	86.14	5.635
Upbeet - NA 308	0.01175 + 0.375	0.01175 + 0.5	39.1	16.81	315	698	85.63	5.619
Upbeet + Stinger + NA 308	0.0156 + 0.05 + 0.25	fB	38.5	16.72	359	721	85.31	5.500
Upbeet + Betamix + Nortron	0.0156 + 0.25 + 0.25	fB	38.9	16.38	406	715	85.33	5.426
Upbeet + Betamix + Nortron + Stinger	0.0156 + 0.25 + 0.05	fB	39.0	16.25	447	743	84.93	5.385
Check	-	-	36.3	16.77	383	672	85.97	5.229
Mean			38.8	16.52	369	697	85.58	5.785
LSD (0.05)			2.2	0.518	71	63	0.89	0.431
CV (%)			3.4	1.9	6.7	5.5	0.63	4.72

Table 6. Root yield, root quality, and sugar yield from herbicides applied as laybye applications. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Herbicide	Rate	Root yield	Sucrose	NO$_3$N	Conductivity	Extraction	Sugar
	lbs ai/ac	t/ac	%	ppm	mohm's	%	t/ac
Roneet	4.0	38.83	16.22	424	720	85.23	5.363
Prowl	1.0	35.73	16.28	468	770	84.58	4.924
Prowl	1.5	34.38	15.61	492	842	83.48	4.479
Prowl	2.0	33.97	15.78	502	874	83.10	4.453
Dual	2.0	40.38	16.47	363	679	85.81	5.711
Dual	4.0	39.91	16.52	347	682	85.78	5.657
Sonalan	1.0	37.74	16.02	471	772	84.49	5.138
Sonalan	1.5	37.74	15.70	488	830	83.66	4.959
Check	-	36.30	16.27	383	672	84.56	4.999
Mean		37.36	16.07	437	771	84.52	5.086
LSD (0.05)		1.67	0.38	72	53	0.752	0.238
CV (%)		3.4	1.8	6.7	5.3	0.686	3.61

THE RESPONSE OF SIX SUGAR BEET CULTIVARS TO NITROGEN FERTILIZATION

Charles E. Stanger and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Purpose

The response of sugar beet cultivars to N fertilization was tested for four years prior to 1993 to determine if cultivars differ in nitrogen requirement to maximize sugar production. This study continued in 1993 to conclude a five year evaluation and furnish data results to the Amalgamated Sugar Company and the sugar beet growers in the Nyssa/Nampa sugar beet growing districts.

Methods and Materials

The trial was conducted on land rented from Wettstein farms. Soils were sandy loam texture containing 1.0 percent organic matter with a pH of 7.1. Sugar beet cultivars included White Satin PM9, 91, and 62; Betaseed 8422, and American Crystal cultivars ACH-200 and ACH-203.

In 1992 field corn was grown in the field. Following corn harvest the field was deep-chiseled, moldboard plowed, and fall bedded. Sixty pounds of nitrogen and 100 pounds of phosphate per acre were broadcast before plowing.

On April 24 the bedded land was harrowed and the sugar beet cultivars planted on April 26. Cultivars were planted in plots four rows wide and twenty-seven feet long, and furrow irrigated on May 1. Three rates of nitrogen were applied by side-dressing NH_4SO_4 on June 8. Added nitrogen was applied at 0, 100, and 200 pounds per acre in strips eight rows wide. The sugar beet cultivars were planted at random in each fertilizer strip using a strip-plot experimental design. Nitrogen rates were replicated three times. Petioles were sampled from each plot at two-week intervals from June 30 to September 8. Petiole sampling and analysis was done by Amalgamated Sugar Company research staff from the Nyssa factory. Sugar beet plants were harvested on October 16, and 17. The sugar beet roots were harvested from the two center rows of each four-row plot to determine root yields. One sample, each containing eight beet roots, was taken from each of the harvested rows and analyzed at the Nyssa Factory tare laboratory for percent sucrose, brei nitrogen, and conductivity. Percent extractable sugar and sugar yields per acre were calculated.

Harvesting equipment included a triple drum beater with trailing rotating discs to remove the sugar beet tops and crown tissue. The roots were lifted using a single row International sugar beet harvester with wheel pullers. The lifted sugar beets were elevated to the top of a loading cart where sugar beet roots from individual plots were weighed and sampled.

The data including root yield, percent sucrose, brei nitrogen, conductivity, percent extraction, and recoverable sugar per acre for each cultivar and nitrogen rate are included in table 1. Table 2 contains dollar value for sugar beets grown at each rate of nitrogen added. Petiole readings as ppm NO_3N are shown in Figure 1 for each sampling date.

Results

Each sugar beet variety after thinning and when plants had six leaves responded the same to nitrogen added to the soil as NH_4SO_4 at 0, 100, and 200 lbs/ac by side-dressing. Roots yields for each cultivar increase, slightly when N was side-dressed at 100 lbs. Side-dressing an additional 100 lbs/ac (200 lb rate) did not increase root yields. Although root yield increased slightly at the 100 and 200 lb rate compared to the 0 rate, the root yield increase was not enough to be significant when measured at the 5 percent level of significance. Percent sucrose decreased with each increase in added nitrogen. Difference in percent sucrose was not great enough to be significant between the 0 and 100 lb nitrogen rate, but was significantly lowered when 200 lbs of nitrogen was added. Increasing nitrogen rates lowered root quality by increasing conductivity and brei nitrogen, and lowering percent extraction. Sugar yield per acre were similar for the 0 and 200 lb nitrogen rate, but significantly more sugar per acre was produced at the 100 lb added nitrogen rate. Growers' net returns (value of crop minus cost of nitrogen) were about $178.00 per acre more at the 0 and 100 lbs N rate than when 200 lbs of nitrogen was added by side-dressing. Previous studies show that as much as 200 lbs of nitrogen is made available annually to sugar beets from nitrogen mineralization furnished through bacterial breakdown of soil organic matter. This is enough N to produce about 30 tons of roots/acre.

Petiole readings ranged near the optimum desired levels at the 100 lbs N rate. Petiole readings were above the optimum desired levels at the 200 lb N rate. Although petiole readings at the 0 nitrogen rate were below the optimum desired level throughout the growing season, sugar beet plots were able to extract enough N from the soil furnished as carry-over nitrogen, mineralizable nitrogen, and from small amounts contained in the irrigation water, to produce excellent root yields with improved root quality (Figure 1).

Table 1. Sugar yield, root yield, percent sucrose, conductivity, brei nitrogen, and percent extractable sugar for six sugar beet cultivars and three nitrogen rates. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Root yield	Sucrose	Conductivity	Brei NO_3	Extraction	Sugar
	t/ac	%	mohms	ppm	%	t/ac
O Nitrogen						
PM-9	43.32	17.44	596	99	87.08	6.584
WS-91	42.67	17.95	605	126	87.05	6.663
WS-62	43.73	17.54	634	132	86.60	6.644
Beta-8422	40.81	18.38	643	123	86.63	6.507
ACH-200	39.28	18.07	538	76	87.94	6.240
ACH-203	39.47	18.02	616	129	86.92	6.157
Avg.	41.55	17.90*	605*	114*	87.04*	6.466
100 Nitrogen						
PM-9	46.30	17.01	567	112	87.36	6.875
WS-91	44.83	17.69	618	127	86.85	6.886
WS-62	45.97	17.51	588	124	87.19	7.018
Beta-8422	43.04	18.25	618	115	86.94	6.830
ACH-200	42.22	17.68	588	99	87.61	6.536
ACH-203	42.03	18.25	556	117	87.74	6.878
Avg.	44.07	17.73*	584*	116*	87.28*	6.837*
200 Nitrogen						
PM-9	45.84	16.62	680	201	85.83	6.536
WS-91	43.09	16.84	774	260	84.63	6.140
WS-62	43.13	16.90	693	199	85.71	6.242
Beta-8422	42.40	17.46	745	209	85.13	6.311
ACH-200	40.94	16.99	660	201	86.16	6.143
ACH-203	42.03	17.30	688	188	85.96	6.239
Avg.	43.07	17.02	707	210	85.55	6.269
Mean	42.68	17.55	632	146	86.62	6.480

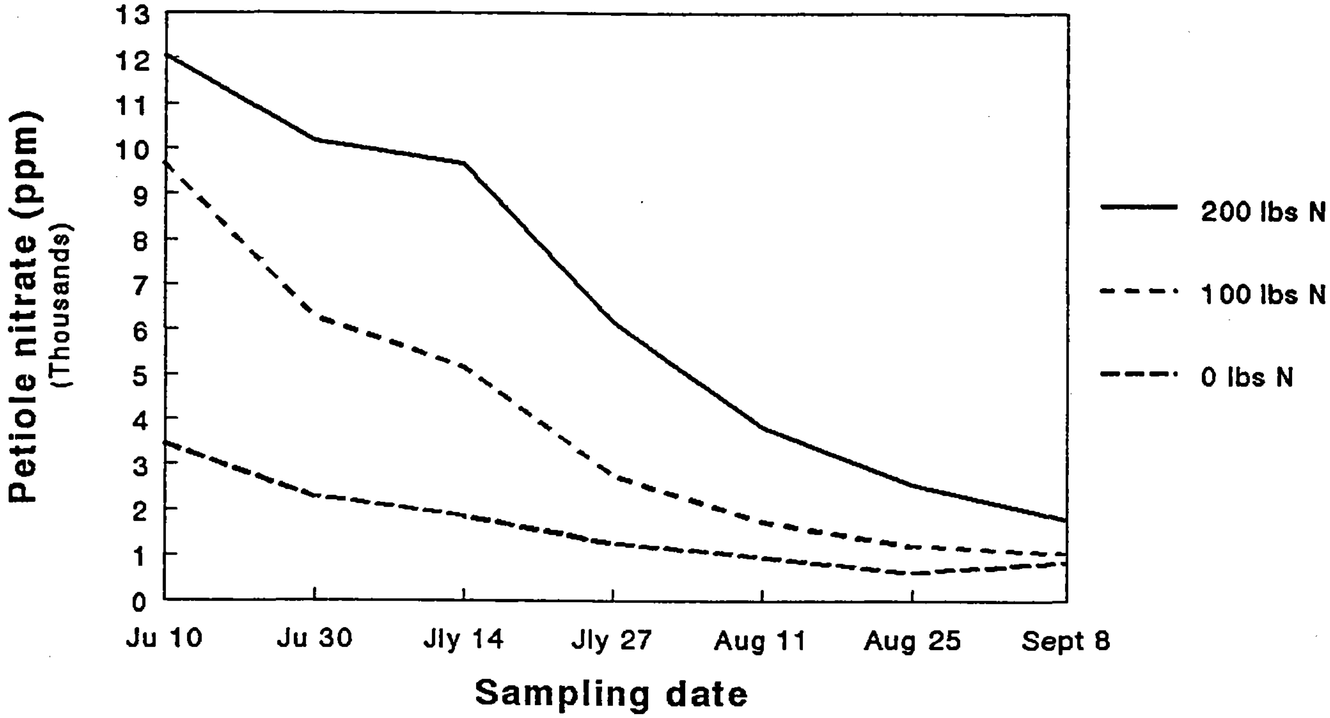
*significant improvement at $P = 0.05$.

Table 2. Average root yield, percent sucrose, and calculated crop value from six sugar beet cultivars when sugar is sold at $22.50 per hundred weight. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Nitrogen	Root yield	Sucrose	Crop value		Crop value minus N cost[1]
lbs/ac	t/ac	%	$/t	$/ac	$/ac
0	41.6	17.36	42.37	1,763	1,763
100	44.2	16.85	40.65	1,806	1,771
200	43.0	16.17	38.67	1,663	1,593

[1] N cost at $0.35 per lb.

Figure 1. Average petiole readings expressed as ppm for seven sampling dates for six sugar beet varieties at three levels of nitrogen applied by sidedressing. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.



Petiole readings for each sampling date are average of six replications for 6 six sugar beet varieties.

EFFECT OF FOLIAR METHANOL APPLICATIONS ON SUGAR BEET YIELD AND QUALITY

Erik Feibert, Clint Shock, J. Mike Barnum and Lamont Saunders
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Introduction

Nonomura and Benson (1992) have recently reported increases in growth and yield of C-3 plants in response to foliar-applied methanol. The trials were conducted in Arizona and responses were only found for methanol applied in the summer and under full sunlight. This trial tested the effect of foliar-applied methanol on the yield and quality of sugar beets, a C-3 plant, grown at high solar intensity in weather cooler than that typical of Arizona.

Procedures

Sugar beet seed of variety HM PM-9 was planted at 149,800 seeds per acre on 22-inch centers on both an Owyhee silt loam (bottom soil) and a Nyssa silt loam (bench soil). Stands were hand thinned to a 7-inch spacing resulting in a population of nearly 40,000 plants/acre.

Plots were six rows wide and 40 feet long, and were arranged in a randomized complete block design with five replicates in each field. The treatments consisted of six methanol solutions and an untreated check (Table 1). The methanol solutions were applied with a backpack sprayer with three 8002 LP nozzles spaced 22 inches apart. Plots were sprayed on July 19, August 2, and August 10 between 1 and 4 p.m. Maximum and minimum air temperatures recorded at the Malheur Experiment Station weather station were 81 and 52 °F for July 19, 92 and 57 °F for August 2 and 89, and 50 °F for August 10. The month average maximum and minimum air temperatures were 80 and 50 °F for July, 84 and 50 °F for August, and 81 and 44 °F for September.

Sugar beets were sprinkler irrigated as necessary. Thirty-six feet of the middle two rows from each plot were harvested on November 2. The beets were weighed and a seven-beet subsample was taken for beet sucrose, nitrate, and conductivity analyses.

Results and Discussion

In the bench soil the 20 and 40 percent methanol solutions applied without Triton X-100, resulted in a significant increase in beet yield and recoverable sugar in relation to the check plot (Table 2).

In the bottom soil the methanol treatments did not result in any significant difference in either beet yield or recoverable sugar. There were significant differences among the methanol treatments for percent sugar, ppm NO_3-N, conductivity, and percent exctraction in the bottom soil. However, the differences were inconclusive as to any trend in response to methanol.

Overall, methanol applications were not associated with an increase in beet yield or recoverable sugar. Overall, no methanol treatment produced more beet tonnage or recoverable sugar than the untreated check.

The summer of 1993 was unusually cool. The maximum air temperature never reached 100 °F. Maximum air temperatures above 104 °F were reported to be common during the trials conducted by Nonomura and Benson. The small but significant increase in beet yield and sugar yield in response to two methanol formulations in one field might be an indication of the existence of a response to methanol, but this interpretation is unlikely due to the lack of response in the other field. The results also suggest that there is no benefit of the use of the surfactant Triton X-100. A continuation of this research under warmer conditions would be more analagous to the experimental conditions of Nonomura and Benson. Due to the considerable expense of methanol applications and the absence of consistent yield responses, growers are cautioned that field applications of methanol will raise sugar beet crop production costs without the likelyhood of yield enhancements.

Literature cited

Nonomura, A.M. and A.A. Benson,1992. Proc. Natl. Acad. Sci. U.S.A. Vol. 89, pp. 9794-9798.

Table 1. Methanol treatments applied to sugar beets. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment	Methanol concentration	Triton X-100 concentration	Total application volume
	--------- %	---------	gal/ac
1	0 (check)	0	0
2	10	0.1	50
3	20	0.1	50
4	40	0.1	50
5	80	0.1	50
6	20	0	50
7	40	0	50

Table 2. Effect of foliar applications of methanol on sugar beet yield and quality. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Field	% methanol concentration	Triton X-100	Beet Yield	Beet sugar content	NO$_3$ content	Conductivity	Exctractable sugar	Sugar yield
			t/ac	%	ppm	mho	%	t/ac
1 (bottom soil)	0	-	17.4	18.0	185.8	0.69	95.7	2.8
	10	+	16.3	18.4	154.4	0.67	95.7	2.7
	20	+	17.1	18.2	147.6	0.65	95.7	2.8
	40	+	17.5	17.8	189.2	0.69	95.6	2.8
	80	+	17.3	18.0	209.8	0.71	95.7	2.8
	20	-	16.9	17.6	270.2	0.77	95.6	2.7
	40	-	17.0	18.2	122.6	0.65	95.7	2.8
	LSD (0.05)		ns	0.6	82.1	0.25	0.1	ns
2 (bench soil)	0	-	12.8	18.5	187.8	0.63	95.7	2.2
	10	+	11.8	18.3	128.7	0.62	95.7	2.0
	20	+	13.4	18.2	198.7	0.68	95.7	2.2
	40	+	13.0	18.0	207.7	0.66	95.7	2.1
	80	+	13.2	18.3	173.5	0.66	95.7	2.2
	20	-	14.5	18.1	251.1	0.71	95.7	2.4
	40	-	14.6	17.8	233.3	0.72	95.7	2.4
	LSD (0.05)		1.4	ns	77.7	0.08	ns	0.2
1 and 2	0	-	15.1	18.2	186.8	0.66	95.7	2.5
	10	+	14.0	18.3	141.6	0.65	95.7	2.3
	20	+	15.3	18.2	173.2	0.67	95.7	2.5
	40	+	15.3	17.9	198.5	0.68	95.7	2.5
	80	+	15.3	18.1	191.7	0.69	95.7	2.5
	20	-	15.7	17.8	260.7	0.74	95.6	2.5
	40	-	15.8	18.0	178.0	0.68	95.7	2.6
	LSD (0.05)		1.6	ns	73.7	0.07	ns	ns

WATER USE EFFICIENCY FOR SUGAR BEET PRODUCTION, 1993 TRIALS

J. Mike Barnum and Clinton C. Shock
Malheur Experiment Station
Oregon State University
Ontario, Oregon

Introduction

Over the last several years the farming community in eastern Oregon and southwestern Idaho has expressed increasing interest in the development and evaluation of water saving irrigation systems and strategies. The primary cause of this increased interest stems from real and anticipated irrigation water shortages like those encountered during the recently ended drought. Interest has been further fueled by increasing public and governmental pressure concerning issues such as ground water contamination, stream flows, salmon survival, and urban water needs.

In 1992, in response to Treasure Valley sugar beet industry concerns over irrigation efficiency, two irrigation management trials evaluating sugar beet response to varying degrees of irrigation stress were conducted at the Malheur Experiment Station (Barnum, et al. 1992). Two similar trials were conducted during the 1993 cropping season. The objectives of these trials were: 1) to determine what yield and sugar losses might result if irrigation was discontinued on July 1 or August 1; 2) to compare production under full season furrow irrigation with full season sprinkler irrigation; 3) to compare irrigation strategies on a bottom soil (shallow water table) and a bench soil (deep water table); and 4) to compare sugar yields from beets grown under different irrigation strategies on both a yield per acre and a yield per acre-foot of applied water basis.

Procedures

During the spring of 1993 two field trials evaluating the effects of six different post emergence irrigation strategies on sugar beets were established in a 3.5 acre field of Owyhee silt loam (bottom soil) and a 4.9 acre field of Nyssa silt loam (bench soil) at the Malheur Experiment Station. The sugar beet variety WS PM-9 was planted at approximately 95,040 seeds per acre (4.0 seeds/ft) on 22-inch centers. A tractor mounted tool-bar planting unit comprised of four John Deere model 71 Flex Planters, fitted with 72 cell plates, disk openers, and depth bands, was used to plant both fields. Following emergence, the seedling stands in both fields were hand thinned to an average 8.7-inch spacing. The resulting mean plant population for the two fields was approximately 32,800 plants per acre.

Three replications of the six irrigation treatments described below were established in each field. The six irrigation strategies evaluated in each field were:

T-1 Furrow irrigate, on 44-inch centers, according to visual indication of crop need for the entire production season (late June through late September).

T-2 Furrow irrigate, on 44-inch centers, applying water at every other irrigation of T-1 (late June through late September). Between seedling emergence and harvest, the total amount of irrigation water applied to this treatment equaled one-half of the amount applied to T-1.

T-3 Sprinkler irrigate according to visual indication of crop need for the entire production season (late June through late September).

T-4 Furrow irrigate, on 44-inch centers, according to visual indications of crop need from beginning of season (late June) until July 1.

T-5 Furrow irrigate, on 44-inch centers, according to visual indication of crop need from beginning of season (late June) until July 1, plus one additional irrigation to refill the soil profile. (This refill irrigation was applied on July 28.)

T-6 Furrow irrigate, on 44-inch centers, according to visual indication of crop need from beginning of season (late June) until August 1.

Because of late snow melt in 1993 and the excessively high amounts of precipitation that fell during early and mid-April, neither field could be prepared for planting prior to the last week of April.

On May 5 a preplant tank-mix application containing 0.75 lbs ai/ac of ethofumesate (Nortron EC) and 2 lbs ai/ac of diethatyl ethyl (Antor 4ES) in 20 gallons of water per acre was broadcast over the entire Owyhee silt loam field and harrowed in. On May 9 the WS PM-9 sugar beet seeds were planted one-half inch deep into dry soil, and a four-inch band of terbufos (Counter 15G) at 1.78 lbs ai/ac was applied over the seed row. To initiate seed germination and promote uniform emergence, the field was furrow irrigated three times between May 13 and May 25. (The total amount of water applied during these three irrigations was approximately 6 acre-inches.)

The WS PM-9 sugar beet seeds were planted one-half inch deep into dry Nyssa silt loam soil on May 10. On May 18 a post-plant pre-emergence application of ethofumesate (Nortron EC) at 2.25 lbs ai/ac in 20 gallons of water per acre was broadcast over the entire field, and a four-inch wide band of terbufos (Counter 15G) at 1.78 oz ai/ac was applied over the seed row. To initiate germination and promote uniform emergence, three successive eight hour sprinkler irrigations were applied between May 20 and May 27. The total amount of water applied during these three irrigations was approximately 6 acre inches. Between the first and second irrigations, glyphosate (Roundup) at 1.0 lb ai/ac in 20 gallons of water per acre was applied to the entire field because of the emergence of a thick stand of seedling watergrass on approximately one-half of the field. At the time the glyphosate application was made, no sugar beet seedlings had emerged.

Following beet seedling emergence and as soon as the soil was dry enough to allow entry, a post emergence tank-mix containing 0.5 lbs ai/ac desmedipham and 0.5 lbs ai/ac phenmedipham (Betamix), 0.22 lbs ai/ac clopyralid (Stinger), 0.3 lbs ai/ac sethoxydim (Poast), and 2.0 pts/ac crop oil concentrate was broadcast over both fields in 25 gallons of water per acre on June 14.

Between June 18 and 20 beets were thinned to the 8.7 inch plant spacing. Following thinning, both fields were cultivated.

The first post-emergence irrigation was applied to all treatments in both fields on June 23. Approximately 3.7 and 3.4 acre-inches of water were applied to each furrow irrigated treatment plot in the bottom soil and bench soil fields, respectively. In both fields an irrigation water inflow rate equalling approximately 144 gallons per hour per furrow was maintained for 24 hours. Approximately 2 inches of water were applied to each sprinkler irrigated plot in each field. The application rate for the sprinkler treatments was approximately 0.2 inches per hour for 12 hours. Until August 28 these flow rates were maintained for all subsequent irrigations applied to each treatment. On August 28, in order to overcome the water flow resistance that resulted from clogging by leaves on the maturing beet plants and deteriorating furrows, irrigation water inflow rates for T-1, T-2, and T-6 were increased by approximately 30 percent in both fields. This increased flow rate was maintained during all subsequent irrigations of those treatments. Application rates for the sprinkler treatments were not increased.

The final irrigation for T-1, T-2, and T-3 was applied in both fields on September 22.

Soil test results from preplant samples taken from both fields showed that approximately 429 and 390 pounds of residual soil nitrogen were contained within the top 3 feet of the Owyhee silt loam and Nyssa silt loam soil profiles, respectively. No additional fertilizer was applied to either field. Petiole test results from samples collected from the most heavily irrigated beets (T-1) at bi-weekly intervals continually showed that N levels were within the range recommended for sugar beet production.

Representative portions of the center two rows in all plots in both fields were harvested on October 28 and 29. Two eight-beet samples were collected from each replicate of each treatment and were sent to the Amalgamated Sugar Company tare laboratory at Nyssa, Oregon for sucrose, nitrate nitrogen, and conductivity analyses.

Results and Discussion

Beet yields from the 1993 trials were significantly lower than beet yields in 1992. The overall performance for well-watered WS PM-9 sugar beets grown on Owyhee silt loam bottom soil (Table 1) was similar to those grown on Nyssa silt loam bench soil (Table 2). Mean beet and net sugar yields for beets grown on bottom soil were, respectively, 15.1 and 15.8 percent greater than for beets grown on bench soil. Likewise, bottom soil beet and sugar yield per acre-foot of irrigation water were 11.9 and 15.6 percent, respectively, greater than bench soil yields.

Mean comparisons (*T* test) between treatment yield variables for the two soils showed that for WS PM-9 sugar beets managed under the strategies for T-2 and T-3, beet and sugar yields on the bottom soil were significantly greater than yields on the bench soil (Figures 1 and 2).

Analysis of the combined data from both fields showed that beet and sugar yields for sugar beets managed under full-season irrigation strategies were significantly greater than were beet and sugar yields for sugar beets managed under the short-season strategies (Table 3). Sugar beets produced under the full season furrow irrigation strategy (T-1) yielded 54.5 and 32.6 percent more beets per acre, and 51.8 and 31.6 percent more sugar per acre than sugar beets produced under the July 1 cut-off (T-4) and the August 1 cut-off (T-6) strategies, respectively.

Sugar beets grown under full season sprinkler irrigation (T-3) averaged 7.7 percent more beets per acre and 5.9 percent more sugar than sugar beets grown under full season furrow irrigation (T-1), but these differences were not statistically significant. The beets grown under the full season sprinkler strategy received 38.7 percent less water than the beets grown under the full season furrow full water strategy.

Differences in beet and sugar yield for WS PM-9 sugar beets grown under the full-season furrow, one-half water strategy (T-2) and WS PM-9 sugar beets grown under the full-season furrow, full-water strategy (T-1) were not significant.

Among the three stressed treatments (T-4 through T-6), per acre beet and sugar yields increased progressively in relationship to the amount of water that was applied during the irrigation season.

Sugar content was significantly greater for WS PM-9 sugar beets managed under the reduced season irrigation strategies (T-4, T-5, and T-6) than for WS PM-9 sugar beets managed under the full season strategies (Figure 4). With the exception of sugar beets grown under the August 1 cut-off strategy, there was no significant difference between treatments in percent extractable sugar.

A comparison of the calculated cumulative ET_c for sugar beets from May 1 through September 30 at Malheur Experiment Station with the cumulative total irrigation water applied to the full season furrow irrigated beets (T-1), and the full season sprinkler irrigated beets (T-3), suggests that the furrow irrigated beets were over-irrigated, and the sprinkler irrigated beets were under-irrigated on both the bottom and bench soils (Figures 3 and 4). The calculated cumulative total ET_c for the period was 28.29 acre-inches of water. During the period, approximately 39.6 and 37.2 inches of water were applied to the furrow-irrigated bottom and bench soil beets, respectively. Approximately 22.8 inches of water were applied to the sprinkler-irrigated beets on both soils.

The average combined yield for beets grown on bottom and bench soil in 1992 was 37.8 tons per acre. The average combined yield for beets grown on bottom and bench soil in 1993 was 22.6 tons per acre. This difference is primarily attributed to the differences in growing conditions between the two years. The 1992 beets were planted in early April. The 1993 beets were planted in early May. In both years there was a similar correlation between irrigation treatments and yield.

Conclusions

1. Both per acre beet and per acre sugar yields for WS PM-9 sugar beets were significantly reduced when irrigation was terminated early.

2. Furrow irrigated WS PM-9 sugar beets receiving 2.1 acre-feet of water between mid-May and mid-September performed nearly as well as furrow irrigated WS PM-9 sugar beets receiving 3.1 acre-feet of water during the same period.

3. Sprinkler irrigated WS PM-9 sugar beets receiving approximately 1.9 acre-feet of water between mid-May and mid-September equaled the beet and sugar yields of furrow irrigated WS PM-9 sugar beets that received approximately 3.1 acre-feet of water during the same period.

4. For WS PM-9 sugar beets maintained under minimal water stress, sugar yield per acre-foot of irrigation water applied was significantly higher for sprinkler irrigated beets than for furrow irrigated beets.

References

Barnum, J.M, C.C. Shock, and L.D. Saunders. 1992. Water Use Efficiency for Sugar Beet Production. p. 191-198. *In* Malheur County Crop Research Annual Report, 1992. OSU. Agric. Exp. Stn. Spec. Rpt. 924.

Table 1. The effects of six irrigation treatments on the yield and quality of WS PM-9 sugar beets grown on Owyhee silt loam bottom soil, Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

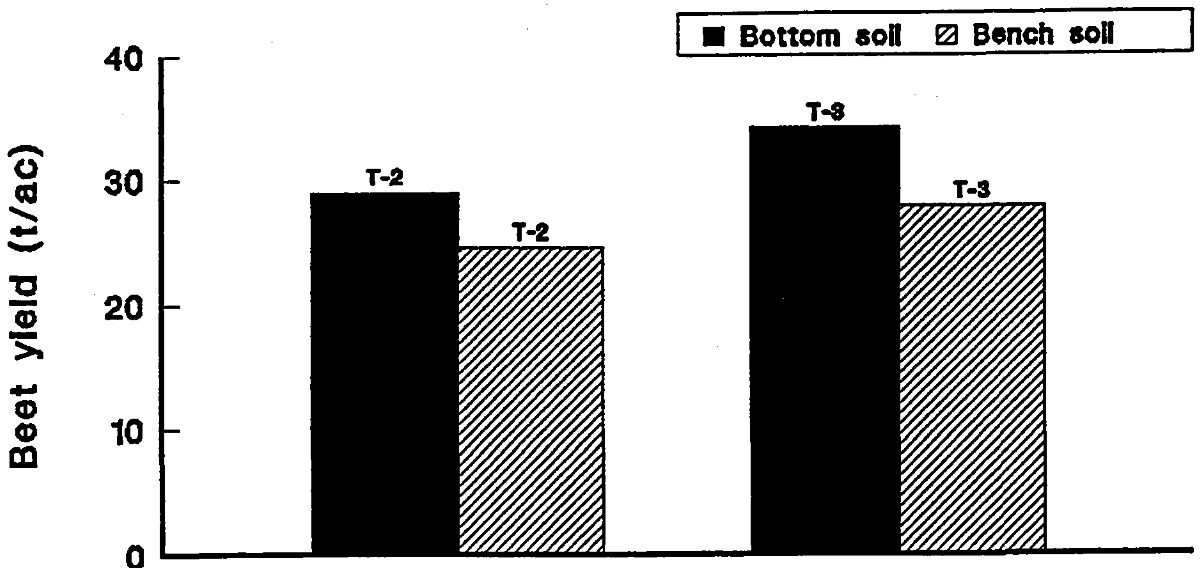
Irrigation treatment	Total water applied	Beet yield	Beet yield per acre ft H_2O	Gross sugar	NO_3 content	Cond.[1]	Net sugar	Sugar yield	Sugar yield per acre ft H_2O
	ac ft	t/ac	t/ac ft	%	ppm	mmhos	%	t/ac	t/ac ft
Furrow, full season	3.3	30.8	9.5	17.6	219	0.7	87.1	4.7	1.4
Furrow, full season, ½ water	2.2	29.0	13.0	18.0	140	0.7	87.5	4.5	2.0
Sprinkler, full season	1.9	34.1	18.0	17.4	234	0.7	86.6	5.1	2.7
Furrow, cut off Jul 1	1.1	14.4	12.9	18.2	249	0.7	87.1	2.2	2.0
Furrow, cut off Jul 1 + 1	1.4	18.7	13.1	18.2	214	0.7	87.1	2.8	2.0
Furrow, cut off Aug 1	2.1	19.8	9.6	18.3	355	0.9	84.8	3.0	1.5
Mean	2.0	24.5	12.7	17.9	235.2	0.7	86.7	3.8	2.0
LSD (0.05)		3.6	2.9	0.7	91.8	0.0	1.1	0.5	0.3
CV (%)		22.3	27.0	5.8	59.0	15.9	1.9	20.6	24.3

[1] Conductivity

Table 2. The effects of six irrigation treatments on the yield and quality of WS PM-9 sugar beets grown on Nyssa silt loam bench soil, Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

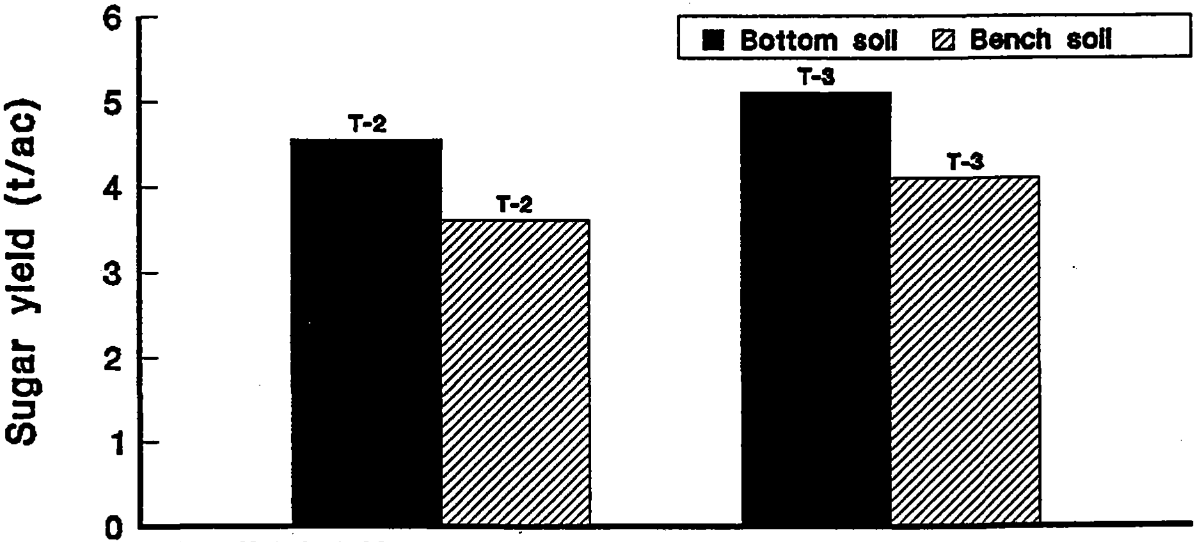
Irrigation treatment	Total water applied	Beet yield	Beet yield per acre ft H_2O	Gross sugar	NO_3 content	Cond.[1]	Net sugar	Sugar yield	Sugar yield per acre ft H_2O
	ac ft	t/ac	t/ac ft	%	ppm	mmhos	%	t/ac	t/ac ft
Furrow, full season	2.9	26.3	9.1	17.5	189	0.7	87.0	3.9	1.4
Furrow, full season, ½ water	2.0	24.6	12.3	17.1	212	0.7	86.7	3.6	1.8
Sprinkler, full season	1.9	27.8	14.7	17.2	202	0.7	86.6	4.1	2.2
Furrow, cut off Jul 1	1.0	11.7	11.2	18.8	163	0.7	87.5	1.9	1.8
Furrow, cut off Jul 1 + 1	1.6	16.0	10.1	18.9	190	0.7	86.6	2.5	1.6
Furrow, cut off Aug 1	1.9	18.2	9.9	18.5	174	0.7	87.1	2.8	1.6
Mean	1.9	20.8	11.2	18.0	188.3	0.7	86.9	3.2	1.7
LSD (0.05)		4.5	2.6	0.7	66.2	0.1	1.0	0.7	0.4
CV (%)		32.9	38.7	6.0	53.2	16.2	1.8	31.1	37.7

[1] Conductivity



T-2: t (0.05)=2.71
T-3: t (0.05)=3.84

Figure 1. Mean beet yields for furrow irrigated (T-2) WS PM-9 sugar beets grown on bottom soil and bench soil with 2.1 acre-feet of water, compared to the mean beet yields for sprinkler irrigated (T-3) WS PM-9 sugar beets grown on bottom soil and bench soil with 1.9 acre-feet of water (T-3). Malheur Experiment Station, Oregon State University, 1993.



T-2: t (0.05)=2.46
T-3: t (0.05)=4.11

Figure 2. Mean sugar yields for furrow irrigated (T-2) WS PM-9 sugar beets grown on bottom soil and bench soil with 2.1 acre-feet of water, compared to the mean sugar yields for sprinkler irrigated (T-3) WS PM-9 sugar beets grown on bottom soil and bench soil with 1.9 acre-feet of water. Malheur Experiment Station, Oregon State University, 1993.

Table 3. The effects of six irrigation treatments on the yield and quality of WS PM-9 sugar beets averaged over a bottom and a bench soil, Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Irrigation treatment	Total water applied	Beet yield	Beet yield per acre ft H_2O	Gross sugar	NO_3 content	Cond.[1]	Net sugar	Sugar yield	Sugar yield per acre ft H_2O
	ac ft	t/ac	t/ac ft	%	ppm	mmhos	%	t/ac	t/ac ft
Furrow, full season	3.1	28.6	9.3	17.5	204.0	0.6	87.0	4.3	1.4
Furrow, full season, ½ water	2.1	26.8	12.6	17.5	176.0	0.6	87.1	4.0	1.9
Sprinkler, full season	1.9	31.0	16.4	17.2	218.1	0.7	86.6	4.6	2.4
Furrow, cut off Jul 1	1.1	13.0	12.1	18.4	205.5	0.6	87.3	2.0	1.9
Furrow, cut off Jul 1 + 1	1.5	17.3	11.5	18.5	202.3	0.7	86.9	2.7	1.8
Furrow, cut off Aug 1	2.0	19.0	9.7	18.3	264.5	0.7	85.9	2.9	1.5
Mean	1.9	22.6	11.9	18.0	211.8	0.7	86.8	3.5	1.8
LSD (0.05)		3.0		0.5	59.3	0.0	0.8	0.4	0.3
CV (%)		28.4		6.0	60.3	16.7	1.9	27.0	31.5

[1] Conductivity

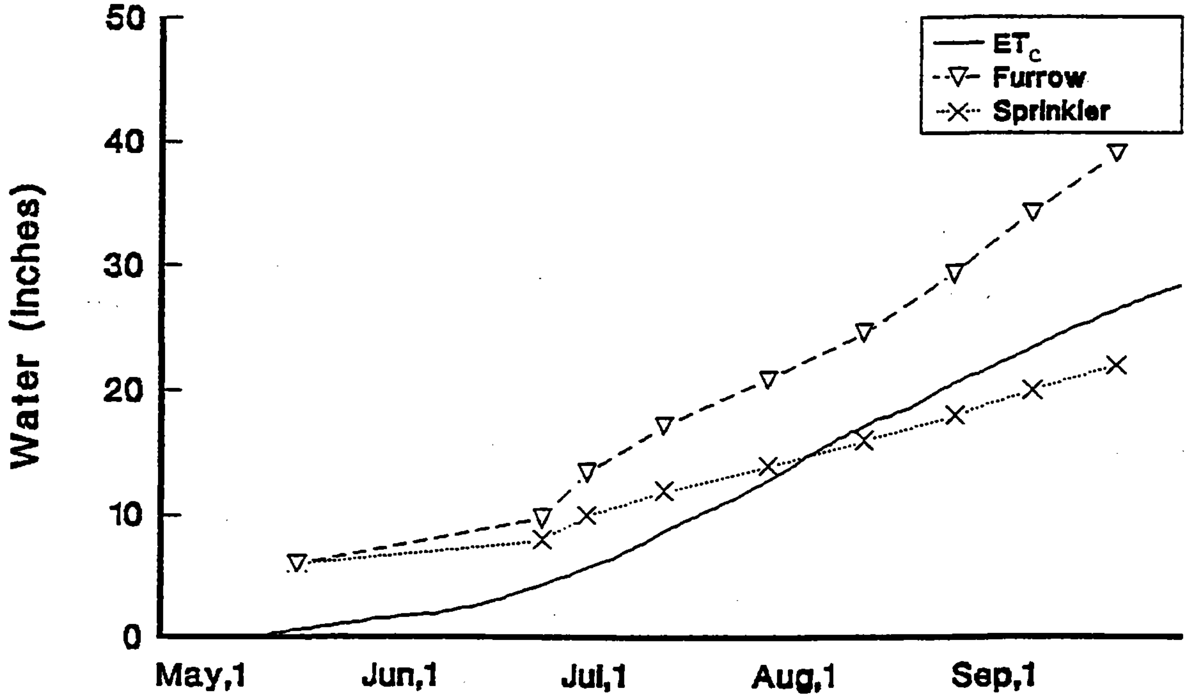


Figure 3. A comparison of cumulative irrigation water applied to full season furrow and full season sprinkler irrigated sugar beets grown on bottom soil to the cumulative calculated sugar beet ET$_C$ from May 1 through September 30, 1993, at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

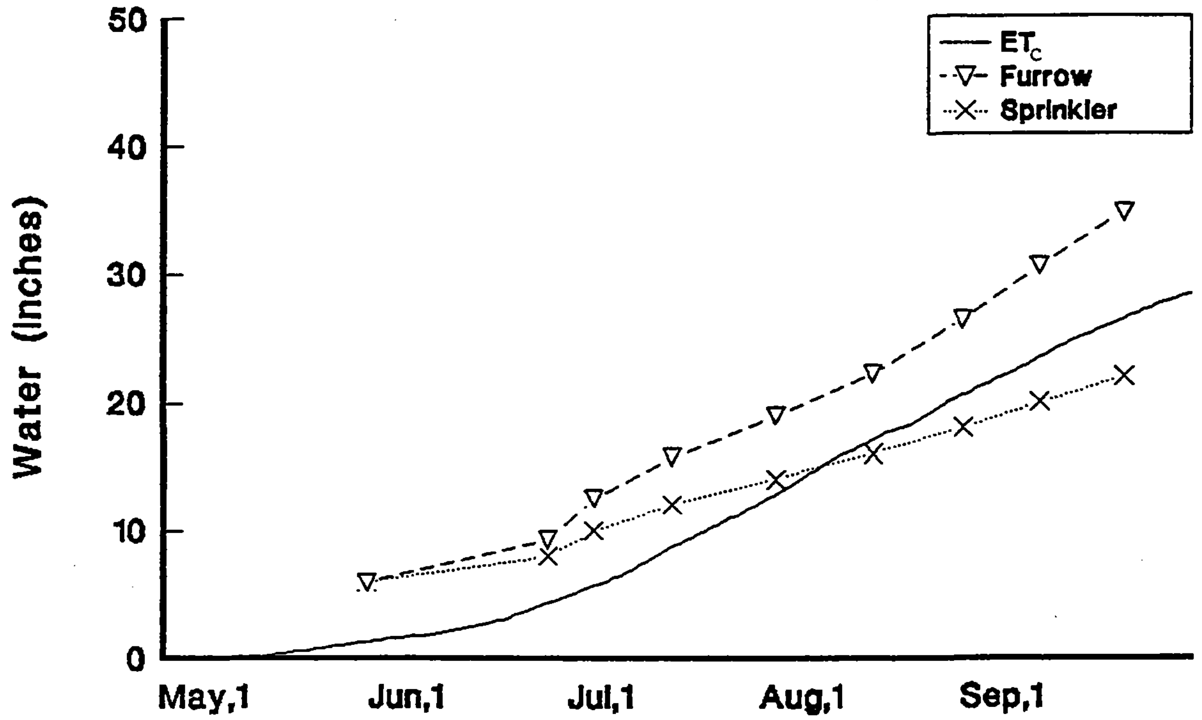


Figure 4. A comparison of cumulative irrigation water applied to full season furrow and full season sprinkler irrigated sugar beets grown on bench soil to the cumulative calculated sugar beet ET from May 1 through September 30, 1993, at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

SUGAR BEET SEED PELLETING INGREDIENTS

Clinton C. Shock and Monty Saunders
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Objectives

Potentially improved sugar beet seed pelleting ingredients were tested to a) evaluate the performance of Tachigaren fungicide at various rates with other fungicides and with Gaucho insecticide in pelleted seed; b) evaluate the potential phytotoxic interaction of Tachigaren and Gaucho; c) provide data to support proposed Section 18 registration submissions in 1994; and d) provide demonstration plots for seed company, university, and grower observation of product performance.

Procedures

Sugar beet seed with different seed pelleting treatments were planted to evaluate the effects of pellet ingredients on diseases and insects, and any positive or adverse effects on seedling emergence, final plant stand, and sugar beet yield and quality. The seed treatments included different rates of the new fungicide Tachigaren and the new insecticide Gaucho (Table 1). Tachigaren is used to control Pythium and Aphanomyces fungi.

The field was fall plowed. Spring ground work began on April 23. Twenty-two-inch beds were harrowed down and 1.5 lb ai/ac Nortron SC was broadcast and incorporated with a bed harrow on April 28.

Sugar beets were planted on April 29 (later than normal) to increase Aphanomyces pressure, if possible. Seed was planted one seed each six inches in rows 22 inches apart. Each seed treatment was planted in 4-row plots 50 feet long, replicated six times, with treatments randomized in a complete block design. Beet plants were counted in the middle 40 feet of the second and third row of each plot on May 11, 13, 18, 26, and at harvest.

There were three cultivations during the growing season, the last was used to incorporate 1 1/2 pints/ac Treflan. Cultivations were accomplished with knives and sweeps. Total fertilizer inputs consisted of 30 lb N/ac as water-run Uran (32% N) on July 10. Thirty lb/ac of sulphur dust was applied two times by airplane for mildew control.

At harvest the beets were topped, counted, and dug. The beets in the middle 40 feet of the two central rows in each plot were weighed, and a seven beet sub-sample from each row was evaluated for tare, sugar content, nitrate, and conductivity. Clean beet yield, estimated percent extraction, and recoverable sugar were calculated.

Table 1. Seed treatments for pelleted sugar beet seed using Gaucho and Tachigaren. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment #	Seed lot§	Seed size	Pellet size†	Pellet type‡	Thiram 30	Apron 25	Tachigaren	Anchor	Gaucho
					---------- g/kg ----------				g ai/kg
1		M	4M	RV5	0	0	0	0	0
2		M	4M	RV5	5	1.25	0	0	0
3		M	4M	RV5	5	0	45	0	0
4		M	4M	RV5	5	0	60	0	0
5		M	4M	RV5	5	0	90	0	0
6		M	4M	RV5	5	1.25	0	0	120
7		M	4M	RV5	5	0	45	0	120
8		M	4M	RV5	5	0	60	0	120
9		M	4M	RV5	5	0	90	0	120
10		M	4M	RV5	5	0	0	1.25	0
11	2M0127	S	2M	RV5	5	1.25	0	0	0
12	2M0127	S	2M	PAT	5	1.25	0	0	0
13	2M0127	S	none	none	5	1.25	0	0	0

§ seed lot 2M0127 had 95 percent germination

† 4M is the regular pellet and 2m is the mini pellet

‡ RV5 is a commercial pellet with some seed steeping and PAT is a "primed advanced treatment" pellet.

Results and Discussion

Seedlings began emerging May 8. Stands were excellent (Table 2). Diseased seedlings were not found. Insect damage was not noted and little significant insect pressure occurred. No late season insecticide was applied.

The unpelleted seed had the lowest emergence on all observation dates, including at harvest. The sugar beets with the PAT (primed advanced treatment) pellets emerged first and were among the best in total emergence on May 11 and May 13 (Table 2). Seed pellet treatments including Gaucho emerged more slowly than the corresponding treatments without Gaucho (68.4 vs 77.6 percent stand on May 11, and 83.7 vs 88.4 percent on May 13). By May 18, the seedling count from Gaucho-treated pellets was equivalent to seedling counts from pellets without Gaucho. No negative effects of Tachigaren, or Tachigaren by Gaucho interactions were observed.

At harvest the unpelleted seed still had significantly lower stand than any of the pelleted seed (Table 3). Differences in stand between the pellet treatments were not statistically significant.

Beet yield, beet quality, and recoverable sugar were not statistically different between seed treatments (Table 4). Differences in yield or recoverable sugar were not expected since the harvested plant stands were excellent in all treatments, ranging from 38,000 to 43,200 plants per acre (80.3 to 90.9 percent).

Conclusions

1. The primed advanced treatment (PAT) pelleted seed enhanced early emergence.

2. All pelleted seed emerged better than raw treated seed in this trial. Raw seed continued to emerge even after May 26.

3. Pellets containing Gaucho insecticide resulted in slower seedling emergence during the first week. Afterwards there was no difference in stand or yield between beets grown with or without Gaucho. Insect pressures were very low at the trial site in 1993, so the protective beneficial effects of Gaucho insecticide could not be observed.

4. There were no statistically negative effects of Tachigaren, or Tachigaren by Gaucho interactions. Although the planting date was delayed to observe potential beneficial effects of Tachigaren, the seedlings suffered no significant disease pressure. Conditions were not favorable to demonstrate Tachigaren benefits.

Table 2. Effect of seed pelleting ingredients on sugar beet emergence over time. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment #	Pellet type	Ingredients	Percent stand by date			
			May 11	May 13	May 18	May 26
			%			
1	RV5	—	75.2	86.3	88.9	88.0
2	RV5	Thiram, Apron	79.4	90.3	89.6	88.9
3	RV5	Thiram, Tachigaren I	78.0	86.5	87.0	88.1
4	RV5	Thiram, Tachigaren II	77.5	87.9	88.8	89.0
5	RV5	Thiram, Tachigaren III	75.4	88.9	88.5	88.5
6	RV5	Thiram, Apron, Gaucho	72.1	85.3	88.2	88.8
7	RV5	Thiram, Tachigaren I, Gaucho	70.7	84.6	87.5	89.4
8	RV5	Thiram, Tachigaren II, Gaucho	68.6	83.3	86.5	87.8
9	RV5	Thiram, Tachigaren III, Gaucho	62.3	81.6	88.2	88.3
10	RV5	Thiram, Anchor	73.5	86.5	87.6	88.8
11	RV5	Thiram, Apron	72.8	85.1	88.9	89.0
12	PAT	Thiram, Apron	87.8	90.3	90.0	89.8
13	none	Thiram, Apron	55.9	70.2	72.5	71.7
	LSD (0.05)		9.3	4.7	4.0	4.3
	LSD (0.05) Tachigaren		ns	ns	ns	ns
	LSD (0.05) Gaucho		4.7	2.3	ns	ns
	LSD (0.05) TXG		ns	ns	ns	ns

Table 3. Effects of sugar beet pelleting ingredients on maximum observed seedling emergence in the spring and in the final stand of beets dug at harvest. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment #	Pellet type	Ingredients	Maximum observed stand in spring	Final stand of beets dug at harvest	
			%	%	plants/ac
1	RV5	—	89.8	86.8	41,200
2	RV5	Thiram, Apron	91.0	90.3	42,900
3	RV5	Thiram, Tachigaren I	88.8	88.9	42,200
4	RV5	Thiram, Tachigaren II	89.7	90.6	43,100
5	RV5	Thiram, Tachigaren III	89.0	89.1	42,300
6	RV5	Thiram, Apron, Gaucho	89.1	89.8	42,700
7	RV5	Thiram, Tachigaren I, Gaucho	89.4	90.1	42,800
8	RV5	Thiram, Tachigaren II, Gaucho	89.7	84.9	40,300
9	RV5	Thiram, Tachigaren III, Gaucho	88.9	86.7	41,200
10	RV5	Thiram, Anchor	89.2	88.4	42,000
11	RV5	Thiram, Apron	89.0	88.0	41,800
12	PAT	Thiram, Apron	90.3	90.9	43,200
13	none	Thiram, Apron	73.1	80.3	38,200
	LSD (0.05) Treatment		3.8	6.4	3,000

Table 4. Effect of sugar beet seed pelleting ingredients on the yield and quality of PM-9 sugar beets. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Treatment #	Pellet Type	Ingredients	Beet yield	Sugar	Conductivity	Pulp N	Extraction	Recoverable sugar
			t/ac	%		ppm	%	lb/ac
1	RV5	---	39.0	17.6	.60	148	88.1	12051
2	RV5	Thiram, Apron	38.1	17.6	.60	139	88.2	11806
3	RV5	Thiram, Tachigaren I	38.5	17.5	.59	143	88.3	11888
4	RV5	Thiram, Tachigaren II	38.0	17.3	.61	156	88.0	11527
5	RV5	Thiram, Tachigaren III	37.7	17.7	.59	131	88.3	11786
6	RV5	Thiram, Apron, Gaucho	39.8	17.6	.61	124	88.1	12304
7	RV5	Thiram, Tachigaren I,	38.3	17.9	.59	140	88.3	12102
8	RV5	Thiram, Tachigaren II,	35.9	17.6	.60	141	88.2	11120
9	RV5	Thiram, Tachigaren III,	37.3	17.5	.59	144	88.3	11500
10	RV5	Thiram, Anchor	39.4	17.3	.65	214	87.5	11903
11	RV5	Thiram, Apron	38.1	17.4	.64	170	87.6	11583
12	PAT	Thiram, Apron	37.8	17.9	.57	112	88.7	12002
13	none	Thiram, Apron	36.1	17.7	.62	142	87.9	11208
	LSD (0.05) Treatment		ns	ns	ns	ns	ns	ns

WEED CONTROL IN SWEET CORN

Charles E. Stanger and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Purpose

Herbicides were applied as preplant incorporated and postemergence applications to Jubilee sweet corn to evaluate herbicides for crop tolerance and control of annual broadleaf and grassy weeds.

Procedures

Preplant herbicides were applied on May 19 to Owyhee silt loam and incorporated with the upper 3 inches of soil using a power driven roto-tiller. The tiller was operated over the plots twice to assure thorough incorporation. The soils had 1.2 percent organic matter with a pH of 7.3. Jubilee variety sweet corn was planted on May 19 and furrow irrigated on the same day. Corn was planted in rows spaced 30 inches apart using a John Deere Model 70 flexi-planter. The preplant and postemergence applied herbicides included Dual, Atrazine, Frontier, Harnass Plus, Permit, and Lasso MT formulation.

Two rates of Permit herbicide were applied postemergence on June 8. The corn plants were about 4 inches tall. Emerged weeds included barnyardgrass, green foxtail, pigweed, lambsquarters, and hairy nightshade. Grasses had 2-3 leaves. Broadleaf weeds were 1/2-1 inches tall. Air temperature was 85 °F and soil temperature at the 4-inch depth was 78 °F. Humidity was 52 percent and wind was 0-2 mph from the southwest. The crop was irrigated three days before the application of postemergence treatments.

Individual plots were four rows wide and 30 feet long. Each treatment was replicated three times. The experimental design was a randomized complete block. All herbicide treatments were applied using a single bicycle wheel plot sprayer. Preplant treatments were applied as broadcast double-overlap applications. Postemergence treatments were applied as banded applications using a four nozzle boom with a spray nozzle centered over the planted row. Spray nozzles were fan teejet, size 8002. Spray pressure was 42 psi and water volume applied in broadcast treatments was 32 gallons/acre. For postemergence treatments water volume was 21 gallons/acre.

Visual ratings for crop injury and percent weed control were recorded on June 14 and 21. To determine corn yield and uniformity of ear shapes, ears from 25 feet of the two center rows of each four row plots were harvested August 6 and 7. The ears were shucked and the corn weighed to determine yields expressed as number of ears and weight in tons/acre. Individual ears were checked for any possible deformity caused by herbicide treatments.

Results

Plant stunting and twisting of corn leaves in the center of the seedling corn plants occurred when Harness Plus, and Frontier herbicides were tank-mixed with Atrazine. In all cases the corn eventually outgrew the herbicide injury without affecting plant height, ear development, maturity date, or corn yields. All pre-plant incorporated herbicides gave good weed control with the exception of Frontier at 1.25 lbs ai/acre. Frontier at this rate was too low to give complete control of redroot pigweed, hairy nightshade, or lambsquarters. Frontier did control barnyardgrass. Frontier did not persist to control late emerging weeds germinating in the irrigation furrows. Permit applied postemergence did not control weeds effectively at the rates evaluated. Permit at 0.063 lbs ai/acre, which was the highest rate evaluated, controlled 87 percent pigweed, 73 percent hairy nightshade, 83 percent lambsquarters, and 17 percent barnyardgrass. Atrazine in tank-mix combination with Frontier, Harness Plus, and Dual controlled all species of broadleaf weeds and barnyardgrass. Lasso MT also gave complete control of all weed species.

Significant differences in the number of ears per acre or deformity of ears were not observed between herbicide treatments. Both number of ears per acre and ear yields were significantly lower in the untreated check plots compared to the herbicide treated plots. Dense weed populations in the untreated checks reduced corn yields and ear number because of plant competition.

Table 1. Crop injury to Jubilee sweet corn and weed control from preplant and postemergence applied herbicides. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

							Percent weed control[2]															
Herbicides	Rate	Applied	Crop injury[1]				Pigweed				H. nightshade				Lambsquarters				Barnyardgrass			
			1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A	1	2	3	A
	lbs ai/ac		---- % ----				%															
Frontier	1.25	PPI	0	0	0	0	95	99	98	97	90	93	98	94	95	90	93	93	99	100	98	99
Dual	2.0	PPI	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Frontier + Atrazine	1.25 + 1.25	PPI	15	15	5	12	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Dual + Atrazine	2.0 + 1.25	PPI	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Harnass Plus	2.25	PPI	15	5	5	8	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Harnass Plus + Atrazine	1.75 + 1.5	PPI	15	5	10	13	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Permit	0.031	POST	0	0	0	0	80	75	75	77	65	60	60	62	70	60	65	65	10	15	15	12
Permit	0.063	POST	0	0	0	0	90	85	90	87	80	70	70	73	80	85	85	83	15	15	20	17
Lasso MT	3.0	PPI	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Untreated Check	-	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[1] Crop injury ratings taken on June 9 and 21. Ratings recorded in table above are June 21 ratings. Ratings taken on June 9 did not show injury symptoms from Atrazine combinations treatments. Injury was curling and knotting of center leaves in the corn plants when 4-6 inches tall.

[2] Ratings: 0 = no herbicide effect, 100 = all plants killed.

Table 2. Jubilee sweet corn yields as affected by herbicides applied preplant incorporated and postemergence. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Herbicides	Rate	Number of ears				Corn yields			
		Rep 1	Rep 2	Rep 3	Avg	Rep 1	Rep 2	Rep 3	Avg
	lb ai/ac	----- ears/ac -----				---------- t/ac ----------			
Frontier	1.25	23542	22641	24201	23460	8.25	7.92	8.38	8.18
Dual	2.0	24603	24107	23911	24210	8.76	8.31	8.01	8.36
Frontier + Atrazine	1.25 + 1.25	24012	24303	24103	24140	7.99	8.12	8.26	8.12
Dual + Atrazine	2.0 + 1.25	22942	24376	23978	23770	7.68	8.42	8.29	8.13
Harnass Plus	2.25	23452	24178	23962	23860	7.75	7.81	7.96	7.64
Harnass Plus + Atrazine	1.75 + 1.5	22643	23491	24301	23480	7.45	7.68	7.79	7.64
Permit	0.031	24611	24722	23767	24370	7.98	8.31	7.87	8.05
Permit	0.063	23917	24711	24111	24250	8.02	8.56	7.74	8.12
Lasso MT	3.0	24311	23966	23477	23920	8.42	7.92	8.14	8.16
Untreated Check	-	21221	20967	19784	20660	6.21	6.42	5.93	6.19
Mean		-	-	-	23610	-	-	-	7.92
LSD (0.05)		-	-	-	1023	-	-	-	0.57
CV (%)		-	-	-		-	-	-	4.20

SURGE IRRIGATION OF WHEAT TO INCREASE IRRIGATION EFFICIENCY AND REDUCE SEDIMENT LOSS, 1993

C.C. Shock[1], L.D. Saunders[1], M. J. English[2], R.W. Mittelstadt[2], and B.M. Shock[1]
[1]Malheur Experiment Station and
[2]Bioresource Engineering
Oregon State University
[1]Ontario, Oregon

Abstract

Treasure spring wheat was grown using conventional furrow irrigation and surge irrigation on 12 one-half-acre plots. Both systems were operated simultaneously five times during the season. Conventional irrigation applied 24.7 ac-in of water with runoff of 5.6 ac-in and infiltration of 19.1 ac-in. Surge irrigation applied 12.0 ac-in with 1.7 ac-in of runoff and 10.3 ac-in of infiltration. Average grain yield under both systems was 128 bu/ac with no significant difference in grain quality. Surge irrigation reduced the loss of sediment in the runoff by 70 percent.

Introduction

Surge irrigation is a process where water is applied to an irrigation furrow intermittently, whereas in continuous-flow (or conventional) irrigation, water is applied to the furrow during the entire irrigation set. With surge irrigation, a switch valve, commonly referred to as a surge valve, is used to cycle water during an irrigation set from one half of the field to the other half.

Preliminary side by side trials comparing surge irrigation with conventional irrigation demonstrated the feasibility of using surge irrigation on silt loam soils in the Treasure Valley. In the 1991 side by side observation trial, spring grain yields were similar between the two systems with substantial water savings on surge irrigation plots. Surge irrigation used 12.9 ac-in of water compared with 28.2 ac-in of water used by conventional irrigation. In 1992, surge irrigation of onions was compared with furrow irrigation of onions for water use, onion yield and grade, and nitrate leaching. Substantial water savings and reduced nitrate leaching were observed, while onion yields were roughly equivalent; however, onion yield and grade diminished down the length of the irrigation row in the surge irrigation plots.

The 1993 surge irrigation trial was designed to compare the effects of surge irrigation with the effects of conventional irrigation on spring wheat yield and quality; water use, infiltration, and runoff; nitrate leaching; and sediment lost in the runoff. In the 1993 surge irrigation trial, a randomized experimental design was used providing replicated plots and resulting in greater certainty of treatment effects.

Procedures

A 6-acre field of silt loam soil was planted April 23, 1993, to Treasure spring wheat at 113 lb/ac. Planting was delayed by late snow melt (March 17) and wet soil conditions. Planting followed fall moldboard plowing and fertilization with 20 lb N, 100 lb P_2O_5, and 10 lbs Zn broadcast to frozen ground in the winter. Previous crops were onions and sugar beets.

Irrigation furrows were bedded out at 30-inch spacing, and the field was divided into 12 one-half-acre plots each 600 feet long, arranged lengthwise down the field. At random, six of the plots were designated as conventional furrow irrigation plots and six were designated as surge irrigation plots. Gated pipe was arranged so that all 12 plots could be irrigated during the same irrigation set. A Waterman Model LVC-5 surge valve automatically oscillated the water from three of the surge irrigation plots to the other three surge irrigation plots. Surges were programmed to range from 39 minutes to one hour long before switching to the other side of the field.

Regardless of irrigation system, only every other furrow was irrigated at about 6.5 gallons/min during any given irrigation. During successive irrigations, the previous dry furrows were irrigated, a pattern that we have called "alternating" furrow irrigation, as opposed to "alternate" furrow irrigation.

On June 6, Bronate was applied using a tractor mounted spray boom at 1 qt/ac to control broadleaf weeds. On July 9 DiSyston EC was applied at 0.5 lb ai/ac by air to control aphids. The west half of the field, the head end of the furrows, received 25 lb N/ac two times as spring broadcast urea. The east half of the field received no fertilizer.

Water and Sediment Measurement

Onset of water inflow and water outflow, and measurements of water inflow rate, water outflow rate, and sediment yield were recorded during each irrigation. Water inflow rates were recorded for every furrow and outflow rates were recorded for every plot. For each water outflow rate reading, a one-liter sample was placed in an Imhoff cone and allowed to settle for 15 minutes. Sediment content in the water, y in g/l, was found to be related to the Imhoff cone reading after 15 minutes (x) by the equation $y = 1.015x$ with $r^2 = 0.98$ and $p < 0.0001$.

Composite water samples were collected in 5-gallon buckets to obtain sediment samples for nutrient analysis during each irrigation. Sediment will be analyzed for nitrate-N, ammonium-N, total N, phosphate-P, and total P.

Total inflow, outflow, infiltration, and sediment loss were integrated from field measurements using a Lotus Improv program "InfilCal 5.0" (Shock and Shock, 1993).

During all five irrigations, inflow water samples and outflow water samples were collected from every plot. The collection time of the water was recorded and composite water samples were made in proportion to the water inflow or outflow volume calculated by InfilCal 5.0. Composite water samples will be analyzed for nitrate-N, ammonium-N, and phosphate-P. Net nutrient losses are to be calculated.

Distribution of water infiltrating into the soil along the length of the furrows was determined using a neutron probe to 6 feet deep in one-foot increments. During each irrigation, water flow and infiltration down the length of several furrows were determined by making timed flow measurements at weirs at various distances for each treatment.

Results and Discussion

The crop developed slowly and did not need irrigation until May 11. The crop was irrigated again on June 15, July 1, July 14, and July 29. Irrigation durations were 28, 28, 24, 24, and 24 hours for both irrigation methods. The long delays between irrigations and late crop maturity were caused by weather that was cooler and wetter than normal. Spring wheat evapotranspiration or consumptive use was only 19.6 ac-in for the season.

The conventional irrigation system delivered an average season total of 24.7 ac-in of water, of which 5.6 ac-in was runoff and 19.1 ac-in was infiltration (Table 1). In comparison, surge irrigation applied only 12.0 ac-in of water with 1.7 ac-in of runoff and 10.3 ac-in of infiltration. The distribution of water along the length of the furrows was uniform in the surge plots. Infiltration plus rainfall was less than the crop evapotranspiration in the surge irrigation plots, and the irrigation deficit was made up by the spring wheat extracting residual soil moisture left over from the wet winter and spring (Table 2).

Surge irrigation resulted in a lower percent runoff than conventional furrow irrigation, 13.7 percent vs 22.7 percent (Table 3). In addition, total estimated sediment loss was reduced from 1,383 lbs per acre to 406 lbs per acre (Table 4).

Grain yield and quality were not significantly different between conventional furrow and surge irrigation (Table 5). Surge irrigation is an efficient way to conserve water while sustaining yields. Growers interested in surge irrigation systems should consult their local SCS office for engineering advice, since surge systems are only appropriate for certain fields.

Table 1. Total water applied, runoff, and infiltration during five furrow irrigations of spring wheat using surge and conventional systems. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	By irrigation					
	1	2	3	4	5	Total
Conventional irrigation	- - - - - - - - - - - - ac-in - - - - - - - - - - - -					
Water applied	5.5	5.4	4.4	4.6	4.8	24.7
Runoff	1.3	1.1	1.0	0.8	1.4	5.6
Infiltration	4.2	4.3	3.4	3.8	3.4	19.1
Surge irrigation						
Water applied	2.4	2.6	2.3	2.3	2.4	12.0
Runoff	0.4	0.5	0.1	0.2	0.5	1.7
Infiltration	2.0	2.1	2.2	2.1	1.9	10.3
Comparison						
LSD(0.05) Water applied	0.4	0.1	0.2	0.4	0.2	0.8
LSD(0.05) Runoff	0.7	0.5	0.2	0.3	0.3	1.0
LSD(0.05) Infiltration	0.4	0.5	0.4	0.3	0.2	1.2

Table 2. Water budget for conventional and surge irrigated spring wheat using alternating furrow irrigation. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Irrigation method	
	Conventional	Surge
	ac-in	
Infiltration of applied water	19.1	10.3
Rainfall (planting to harvest)	3.2	3.2
Total supply for crop	22.3	13.5
Consumptive use (ET_o)	19.6	19.6
Estimated deep percolation	2.7	0
Estimated net extraction	0	6.1

Table 3. Percent runoff of applied water during five furrow irrigations of spring wheat using surge and conventional systems. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Percent runoff by irrigation					
	1	2	3	4	5	Total
	- - - - - - - - - - % - - - - - - -					
Conventional	22.8	19.6	22.8	18.4	30.0	22.7
Surge	17.6	18.4	6.1	6.9	19.6	13.7
LSD(0.05)	ns	ns	4.5	7.1	8.0	5.8

Table 4. Sediment yield in runoff water during five furrow irrigations of spring wheat using surge and conventional systems. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Sediment yield by irrigation					
	1	2	3	4	5	Total
	--------- lb/ac ---------					
Conventional irrigation	477	460	74	127	245	1,383
Surge irrigation	30	166	29	123	58	406
LSD(0.05)	196	ns	ns	ns	102	647

Table 5. Yield, grain weight, and harvest index of soft white spring wheat grown with furrow irrigation and surge irrigation. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Grain yield	Bushel weight	Harvest index
	bu/ac	lb/bu	0 to 1
Conventional			
Surge irrigation	128.2	61.7	.529
LSD(0.05)	ns	ns	ns[§]

[§] different at P < 0.086

MODELING THE DISTRIBUTION OF WATER, SOIL WATER AND NITRATE MOVEMENT, AND SEDIMENT LOSS UNDER FURROW IRRIGATION

M.J. English[1], R.W. Mittlestadt[1], C.C. Shock[2],
S.N. Raja[1], A. Tunio[1] and A. Mitchell[3]
Bioresource Engineering Dept.[1], Malheur Experiment Station[2], and
Central Oregon Ag Research Station[3], Oregon State University

Abstract

Models of the distribution of water in furrows, sediment yield, soil water movement, and the movement of nitrates in the soil profile under furrow irrigation have been acquired and are being calibrated with data collected at the Malheur Experiment Station and on cooperating farms in Malheur County.

Introduction

A project to study potential improvement of furrow irrigation in Malheur County was initiated in 1993. The fundamental purpose will be to identify alternative methods that minimize nitrate leaching and sediment loss in runoff while maintaining farm income and productivity. The project is supported in part by federal funds and is being conducted in cooperation with SCS and Extension Service personnel, as well as with the cooperation of individual farmers in the Ontario area.

The project is using computer models of furrow irrigation processes calibrated with local field data. The research findings from various field studies are being extended to a broader range of circumstances than were encompassed by the original field work. The work planned for this project is proceeding in three phases:

1. Identify and acquire computer models of the relevant processes.
2. Collect field data for calibration and testing of these models under Malheur County conditions.
3. Use the models to analyze furrow irrigation management and system design strategies relevant to Malheur County conditions.

Procedures

During the first phase of the project, three relevant models were identified and acquired. The models were installed on computers at Oregon State University in Corvallis and at the Malheur Experiment Station. They include:

- SRFR, a model of furrow hydraulics that simulates the movement of water down a furrow, the infiltration of water into the soil along the length of the furrow, and tail water runoff.
- SWMS2-D, a two-dimensional model of water movement in the soil under unsaturated and saturated conditions. This model also simulates movement of solutes, i.e. nitrates, as a consequence of the movement of water.

- FUSED, a model of erosion and sediment yield in furrows as a function of furrow slope and length, and the water inflow rate at the head of the furrow.

After installing and using these models for a period of several months, questions arose concerning how best to utilize the models, how to modify them to meet the particular needs of this project, and how to interpret model output. The authors of each model were invited to Oregon for consultation and to help with revisions. Those visits took place during November and December 1993, and resulted in significant refinements and improved performance of the SWMS2-D and FUSED models, as well as a better understanding of all three models.

The second phase, collection of data for model calibration and testing, began during the 1993 growing season. The bulk of this work was done in two fully instrumented fields at the Malheur Experiment Station. Additional data were collected on several cooperating farms in the vicinity of Ontario. Data were collected for a range of conditions; wheat, corn, dry beans, and sugar beet crops on various soil types, using surge and continuous furrow irrigation, in straw-mulched and non-mulched fields, in furrows that had been compacted by wheel traffic, and in uncompacted, non-wheel traffic furrows. The data collected included:

- Soil moisture distribution in furrows before and after irrigations. These data were taken with neutron probes.
- Water movement in furrows, including inflow rates, advance rates, flow rates through flumes at intermediate points in the furrows, and tail water runoff at the ends of furrows.
- Precise measurements of infiltration rates as a function of time and wetted perimeters in 20-foot-long sections of furrows. A recirculating infiltrometer was used for this work.
- Measurements of sediment concentrations in furrow flows, and sediment yield at the ends of furrows.
- Measurements of nitrate concentrations in furrow tailwaters.
- Soil physical characteristics, including water retention characteristics and "basic" infiltration rates.

Results and Discussion

The data collected during the 1993 season are too voluminous to present in detail in this report. However some of the data are of immediate interest to the grower. These are presented below.

Water Distribution in Furrows

Soil water distribution in furrows under both surge and continuous irrigation, as determined by neutron probes installed along the length of the furrow, are presented in Figures 1 and 2. These represent composite data from seven furrows for two irrigations. The field length was 610 feet, slope was 0.50 percent and inflow rates to the furrows were 6.3, 5.8, and 5.4 gallons per minute for the three irrigations, respectively. Readily available soil water was calculated as soil moisture in excess of

20 percent by volume (approximately 1.5 bars of tension). Soil moisture at 15 bars of tension was determined to be 15 percent by volume. A fourth set of data (from a fourth irrigation) is not presented because of doubts concerning the reliability of the neutron probe instrument on that occasion. Corrections were made for crop evapotranspiration (ET_c) between the dates of soil moisture measurement using AGRIMET daily ET_c estimates.

Data collected on furrow advance rates for three irrigations indicate a significantly faster advance in compacted furrows (Figure 3). However the soil water distribution data seem to indicate that the difference in advance rates did not significantly alter the relative distribution of water in the wheel and non-wheel furrows.

Sediment Yield

Sediment losses from the same field discussed above are presented in Figure 4 for plots within the field and for successive irrigation. Recall that for each irrigation, water was applied to alternating furrows. Sediment losses are presented for five successive irrigations. The yield of sediment under normal irrigation practices, and in particular the heavy sediment load produced by the first irrigation, is indicated by these data.

Current Status

The models are operational at this time and have been used to conduct limited, preliminary analyses. Further data will be collected in the coming irrigation season to further refine and test the models. Full scale studies of alternative irrigation methods will begin at the end of the coming season after completion of the testing phase.

Figure 1. Readily available soil water in the top 2 and 6 feet of a greenleaf silt loam prior to and after the first furrow irrigation using continuous or surge irrigation in alternate furrows. Readily available water for wheat was calculated as water above -150 cbars (cb = kPa = Jkg^{-1}). Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

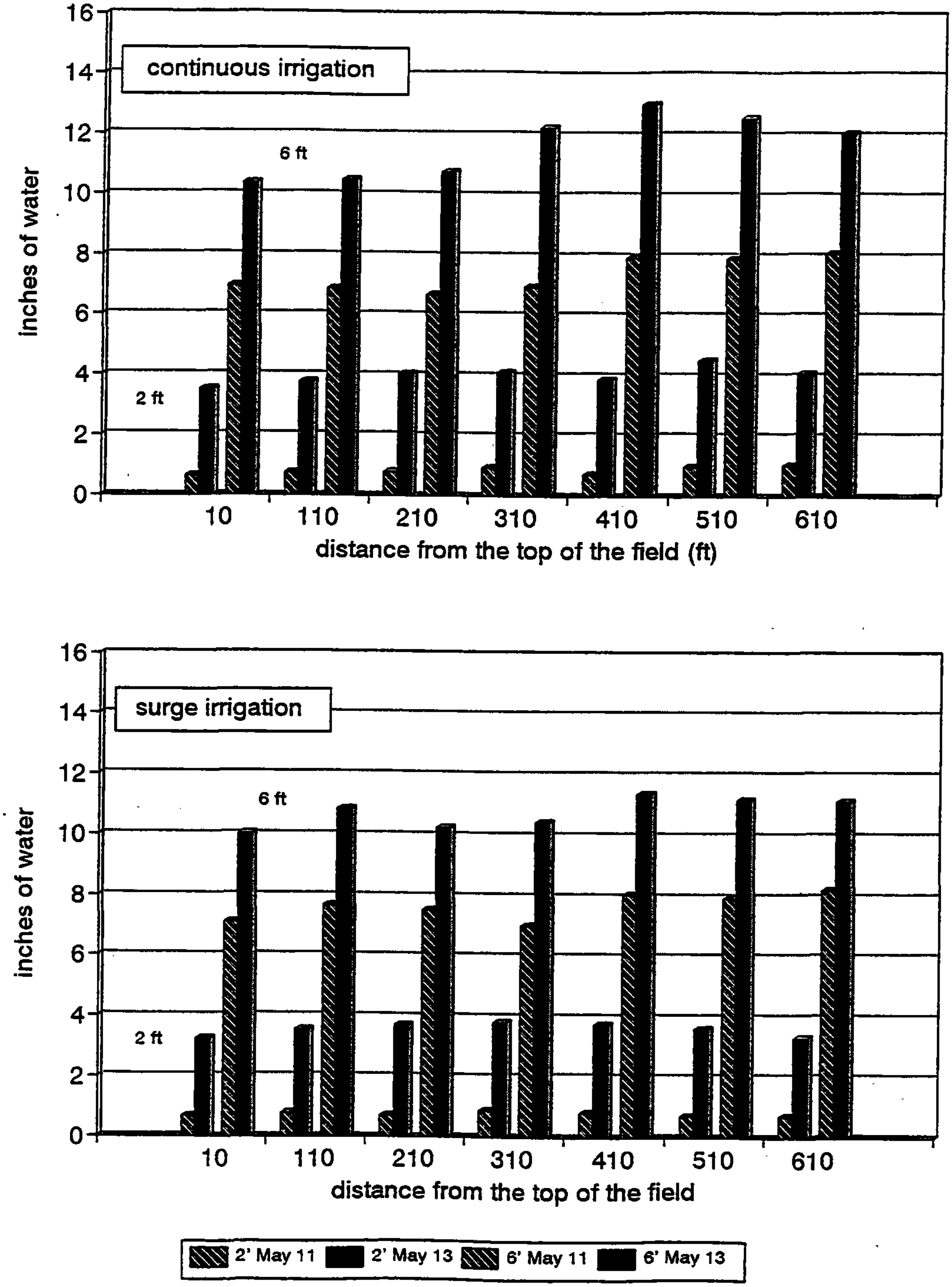


Figure 2. Readily available soil water in the top 2 and 6 feet of a Greenleaf silt loam prior to and after the second furrow irrigation using continuous or surge irrigation in alternate furrows. Readily available water for wheat was calculated as water above -150 cbars (cb = kPa = Jkg^{-1}). Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

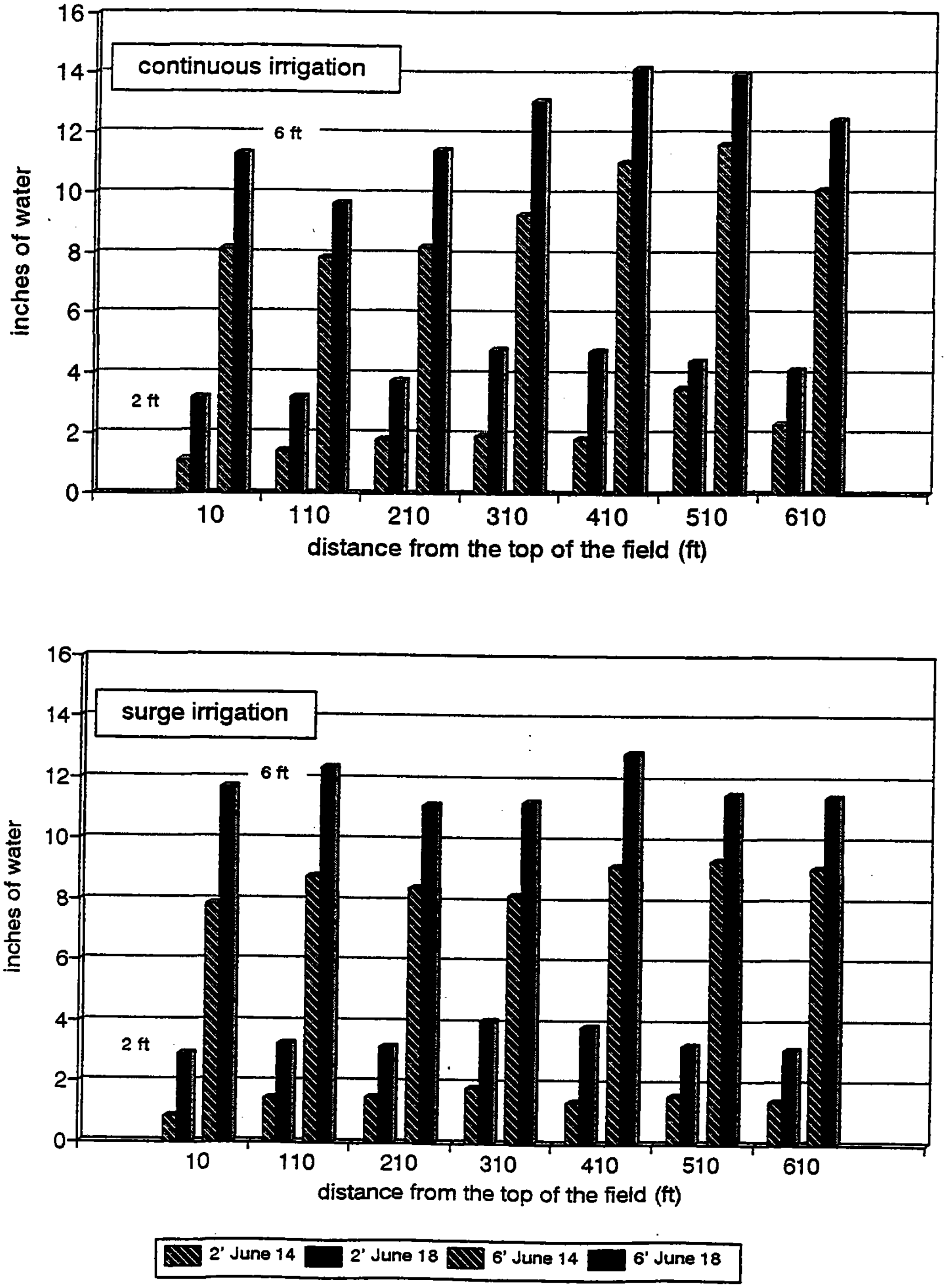


Figure 3. Irrigation water advance times during three continuous and surge irrigations. Advance rates were measured in compacted wheel traffic furrows and uncompacted non-wheel traffic furrows on a Greenleaf silt loam. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

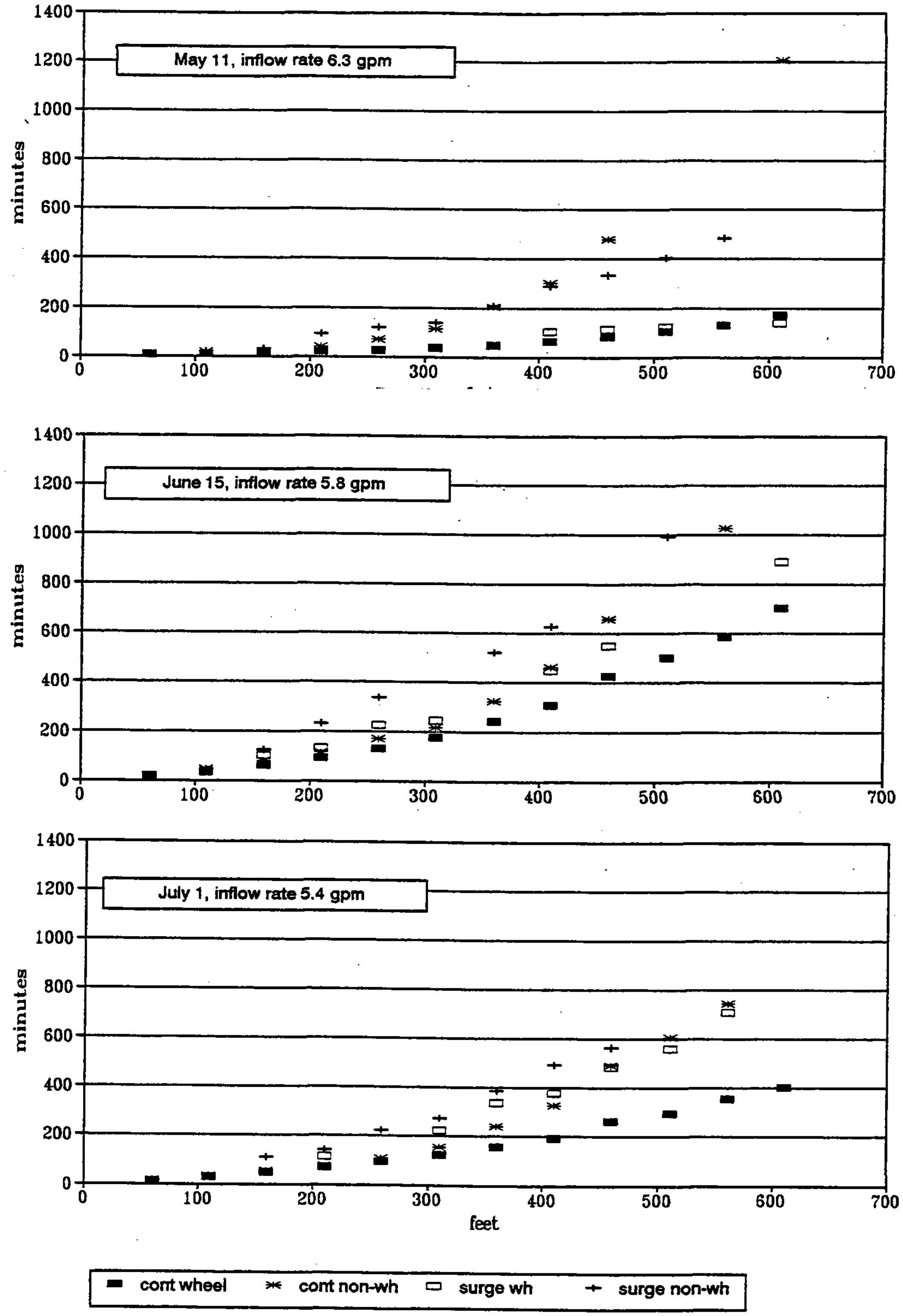
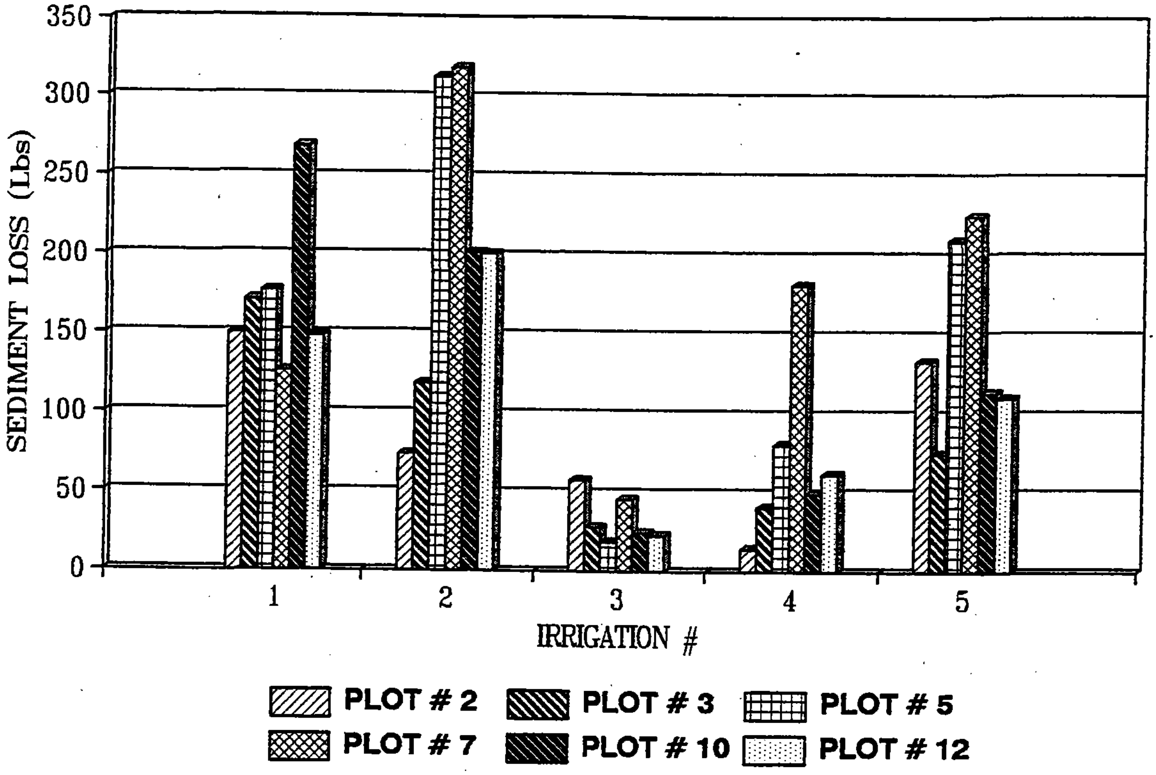


Figure 4. Total sediment loss from each plot for five continuous irrigations on alternating furrows. Data was collected for each plot from compacted wheel traffic furrows and uncompacted non-wheel traffic furrows on a Greenleaf silt loam. Each plot consisted of seven irrigated furrows. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.



INTEGRATION OF GRANULAR MATRIX SENSORS FOR SOIL WATER MONITORING INTO AGRIMET AND HYDROMET

Clinton C. Shock and J. Mike Barnum
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Purpose

An AgriMet weather station and granular matrix sensors (GMS) were installed at the Malheur Experiment Station, Ontario, Oregon, to test the capability of near real-time GMS data acquisition through the AgriMet automated network. AgriMet reading, transmission, and interpretation of GMS data was accurate and reliable. Data showed clear wetting and drying oscillations associated with snow melt, rainfall, irrigation, and non-irrigated periods. From April 1992 to December 1993 GMS performance was stable and reliable; no sensor replacement or maintenance was required.

Introduction

AgriMet

AgriMet is an automated agricultural weather station network operating throughout the Pacific Northwest. AgriMet is integrated into the larger HydroMet network designed to provide real time data management for reservoir and river operations throughout the Pacific Northwest. AgriMet uses site specific climatic data and crop models to estimate crop water use.

AgriMet and HydroMet could benefit from soil moisture information. Soil water content estimates from snow measurement sites could improve water runoff estimates. Soil moisture data from irrigated crop land could help refine crop water use estimates.

Irrigation Scheduling

Irrigation of crops sensitive to water stress requires some system of irrigation scheduling to manage irrigation decisions. Information to manage irrigation decisions may include atmospherically-based, plant-based, or soil-based data (Heerman, et al., 1990). Examples of atmospheric based irrigation scheduling information are weather forecasts and pan evaporation measurements. Plant data may include canopy temperature and visible wilting. Soil-based data may include soil water content and soil water potential. In practice, plant, soil, and atmospheric data are often used concurrently, especially when changes in irrigation scheduling are required to adjust for changes in crop water use.

Soil-based irrigation scheduling methods range from the simple "feel" method to such technologically advanced methods as the neutron probe and time-domain reflectometry (Campbell and Mulla, 1990). Tensiometers and gypsum blocks provide technology at reasonable cost between these extremes, but they have limitations for practical use by growers. Tensiometers require continual service, a high level of skill in installation and management, and tensiometers are only accurate in the 0 to -70 J kg^{-1} (J kg^{-1} are equivalent units to kPa and centibars) range of soil water potential. They have a reduced range in coarse-textured soils (Cassel and Klute, 1986). The water content of gypsum blocks, or any porous absorber placed in firm contact with soil, depends on the soil water potential and not the water content of the soil (Gardner, 1986). Gypsum blocks are manufactured at different sensitivities by mixing the plaster to obtain different ranges of pore sizes (Campbell and Gee, 1986). The blocks will slowly dissolve, may lose firm contact with the soil, and may respond inconsistently to soil moisture changes. Because of these limitations, tensiometers and gypsum blocks have not gained wide acceptance for irrigation management.

Granular Matrix Sensors

A granular matrix sensor (GMS) for electronically measuring soil moisture was patented by Larson in 1985. The GMS is marketed as "Watermark" sensors by Irrometer Co. of Riverside, California. The GMS technology reduces the problems inherent in gypsum blocks of inconsistent pore size distribution, and loss of contact with the soil through dissolving. The GMS uses an insoluble granular fill material held in a fabric tube supported in a metal or plastic screen. These sensors operate on the same electrical resistance principle as gypsum blocks and contain a wafer of gypsum imbedded in the granular matrix below a pair of coiled wire electrodes. The electrodes inside the GMS are imbedded in the granular fill material above the gypsum wafer. The gypsum wafer slowly dissolves to buffer the effect of salinity of the soil solution on electrical resistance between the GMS electrodes. According to Larson (1985), particle size of the granular fill material and its compression determines the pore size distribution in the GMS and its response characteristics.

GMS calibration using a pressure plate apparatus was described by Thomson and Armstrong (1986), by Wang and McCann (1988), and by Eldredge et. al. (1992); however, the published reports are not in agreement on the resulting calibration equation for the Watermark Model 200.

Recently, Shock and Barnum (1992) related GMS readings to soil water potential, closely confirming the calibration curve of Eldredge et. al. (1993). Shock and Barnum calibrated two additional GMS designs (Watermark Models 200SS and 200SSX). These designs substitute a stainless steel screen for the plastic of the Model 200, allowing more uniform particle compaction and greater surface area contact between the soil and the granular matrix.

Recent GMS research at the Malheur Experiment Station has been supported by the Oregon Potato Commission, CAAR, and Irrometer. Ongoing research objectives have included effects of soil texture, salinity, and temperature on GMS response. GMS placement in potato beds, and the number of sensors necessary to accurately predict soil water potential are also being studied. Alternative sensors are being examined. Sensor time delays to wetting and drying have been evaluated.

Objectives

A. Test the telemetry of GMS in the AgriMet seasons.

B. Test the durability of GMS when used during all seasons.

C. Evaluate GMS accuracy.

Procedures

An AgriMet station was established at the Malheur Experiment Station (MES) by the Bureau of Reclamation (see Appendix). A total of 16 GMS (Model 200 SS and 200 SSX, Irrometer Co., Riverside, CA) were installed. Half of the GMS (Model 200 SSX) were monitored regularly by the AgriMet station, and data was transmitted regularly via satellite to the network headquarters in Boise, Idaho. The other eight GMS (Model 200 SS) were read daily at 8 a.m. using a hand-held meter (30 KTCD meter, Irrometer Co., Riverside CA) that had been calibrated to soil water potential (Eldredge et al, 1993). Granular matrix sensors were placed at 8- and 20-inch depths under an alfalfa canopy. Soil temperature probes will be placed at 8 and 20 inches to assist in correcting GMS resistance to estimates of soil water potential.

Granular matrix sensors were calibrated against tensiometers, a neutron probe, and gravimetric soil sampling during several wetting and drying cycles at the Malheur Experiment Station. Tensiometer, neutron probe, and soil gravimetric water content measurements were exclusively ground based data.

Table 1. GMS number, models, and placement.

Number of GMS	Sensor Model	Sensor Depth
4	Watermark 200 SS	8 inches (20 cm)
4	Watermark 200 SS	20 inches (50 cm)
4	Watermark 200 SSX	8 inches (20 cm)
4	Watermark 200 SSX	20 inches (50 cm)

MES staff have related GMS resistance to tensiometer readings, neutron probe, and gravimetric readings using regression and appropriate soil physics relationships (Mualem, 1976, and van Genuchten and Nielsen, 1985).

Results and Discussion

During 1992 daily visual tensiometer measurements, manual GMS meter measurements, and AgriMet GMS data were collected. By the end of 1992, useful calibrations of AgriMet GMS data were installed in the Bureau of Reclamation computer in Boise, Idaho. Daily measurements for all of 1993 are available.

AgriMet GMS Data Compared to Tensiometers

During the irrigation season, AgriMet GMS data closely corresponded to each wetting and drying cycle in the alfalfa field. Irrigations on June 19, July 10, August 3, and August 13 were clearly recorded by AgriMet at both the 8-in and 20-inch soil depth (Figures 1 and 2). Comparison between AgriMet GMS data and tensiometers was close, except that the tensiometers start to become insensitive at soil drier than -70 kPa. When the soil was drier than -70 kPa tensiometer maintenance was impossible, while GMS continued to be operational. Tensiometer data was unreliable in late July, when individual tensiometers failed, so their average values were not meaningful.

During early April 1993, repeated rainfall events saturated the soil surface so the soil water potential reached -0 kPa. Both tensiometers and AgriMet GMS data at the 8-inch depth reflected the saturated soil condition (Figure 3). Simultaneously, the soil at the 20-inch depth was not saturated. As spring progressed, the alfalfa crop grew and the soil dried in spite of many small rainfalls. Both tensiometer and AgriMet data tracked this wet to dry cycle very well (Figure 3).

AgriMet GMS soil water potential at the 8-inch depth and at the 20-inch depth are comparable to tensiometer soil water potential during the entire year with the exception that tensiometers are subject to freeze damage from October through March and tensiometers are unresponsive where the soil water potential dries past -70 kPa (Figures 4 and 5). Tensiometers were removed in the fall and reinstalled in the spring to avoid freezing. Periods of snow melt, substantial rainfall, irrigation, and water use were closely followed by AgriMet. GMS resistance was always lower by 6 a.m. if irrigation had been started the previous day. GMS always responded as quickly as tensiometers.

GMS Measurements By Meter and AgriMet

GMS measurements using the 30 KTCD meter were similar to AgriMet GMS measurements during the growing season at both the 8- and 20-inch depths (Figures 6 and 7). Meter readings were less sensitive to the driest periods at the 8-inch depths (Figure 6). The meter, as currently calibrated for the wet range in silt loam soils, is less sensitive to the drier soil water potentials. Meter limitations are evident when GMS measurements are compared over the entire year at 8-inch and 20-inch depths (Figures 8 and 9). Meter limitations were made more acute by the authors, because we changed the internal calibration of the meter so that it was highly accurate for silt loam soils in the wet range. As a consequence, sensitivity was lost in the dry range. The added precision and responsiveness observed with AgriMet GMS data collection and interpretation compared to manual use of the 30 KTCD meter is similar to enhanced precision and responsiveness achieved by Shock and Barnum (1992) using a Campbell 21X datalogger.

Converting AgriMet GMS Data to Soil Water Potential and Soil Water Content

Granular matrix sensor resistance as measured by AgriMet varied continuously during the last year and a half. Data could be interpreted as resistance in kohms, or converted to soil water potential or soil water content (Figures 10 and 11).

AgriMet GMS data was converted to soil water potential. The regression equation between soil water potential (S in kPa) determined by tensiometers, and GMS Model 200SSX resistance (X in kohms) in silt loam soil was expressed by the equation

$$S = -\frac{(2.159 + 0.004102X)}{(1 - 0.01397T)} \qquad R^2 = 0.96$$

where T is the temperature in degrees centigrade. This equation is most accurate at soil water potentials in the range of tensiometers (0 to -70 kPa), and in the range of soil temperatures during the irrigation season (15 to 25 °C).

AgriMet GMS data was converted to soil water content. The regression equation between GMS Model 200SSX resistance (X in kohms) and soil volumetric water content (θ_v in percent) in silt loam soil was expressed by the equation

$$\theta_v = (33.73)\,(0.9711)^X \qquad r^2 = 0.80.$$

Soil volumetric water content was calibrated in the range of 10 to 34 percent. Examining the AgriMet GMS data converted to soil water content provides continuous information for the year at both the 8-inch and 10-inch depths (Figures 10 and 11, respectively).

Conclusions

Telemetry of GMS data through the AgriMet automated weather station network was accurate and reliable. Interpretation of AgriMet GMS data showed clear wetting and drying responses in the normal irrigation range of soil water potential (0 to -70 kPa) in a silt loam soil. During the irrigation season, AgriMet measurements of soil water potential were sensitive and accurate compared to measurements made manually with tensiometers or GMS using a hand-held 30 KTCD meter, suggesting that AgriMet GMS data could be of benefit in irrigation scheduling. GMS consistently responded to irrigation within 24 hours. Lower resistance was noted for GMS whenever tensiometers indicated wetter soil.

AgriMet GMS readings were more responsive and accurate over a wider range of soil water contents than tensiometer or hand-held meter readings. AgriMet GMS data provided measurements of soil water content all year.

The AgriMet collection utilizes a large range of GMS sensitivity for drier soil to the extent that additional refinements of calibration beyond this present work in the range of soil drier than -100 kPa and at soil temperatures near 32 °F are desirable.

Over the period April 1992 to December 1993, GMS performance has been stable and reliable without need for sensor replacement or maintenance.

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Appendix of installed equipment

RM Young Wind Monitor Model #05103
Vaisala Relative Humidity Sensor W/Radiation Shield - Model # HMP-35A
Qualimetrics Tipping Bucket Rain Gauge
Free-Standing Tripod
Gill Multiplate Temperature Shield
Data Collection Platform Model #8004-0011
Multiplexers
Yagi Antenna Model # DB437 / Cable
Battery - 190 AMP-HR
Power Supply Cable
Solar Panel - 10 Watt Model # SX-10
Solar Panel Voltage Regulator
LI-Cor Pyranometer Sensor w/ Leveling Fixture - Model # LI-200SB
PAR Sensor
5 Thermistors Model # YSI44212 (air, water, soil at 4", 8", and 20")
Burgess Integrators - Solar & Windrun
NEMA-4 Enclosure
Hobson-Type Enclosure
8 Watermark Soil Moisture Sensors Model 200SS
8 Watermark Soil Moisture Sensors Model 200SSX
8 Irrometer Tensiometers Model R

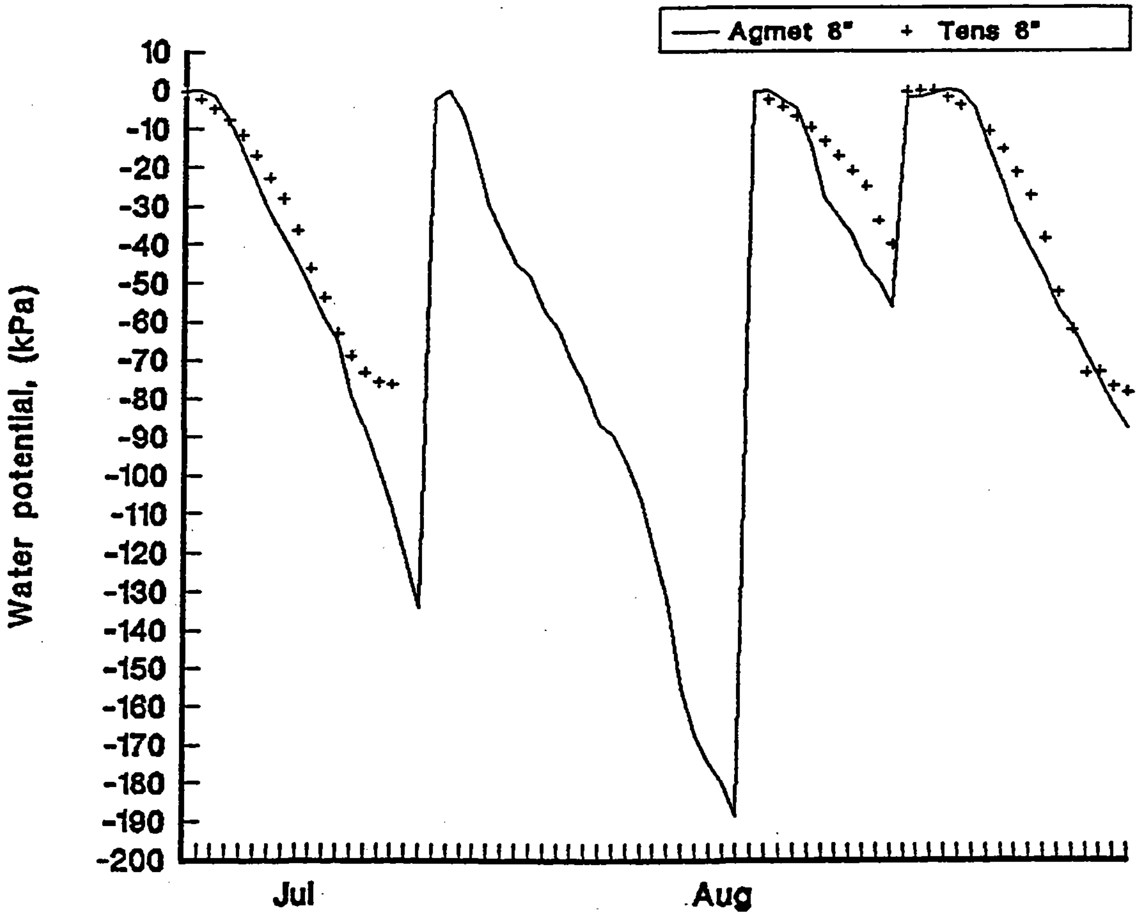


Figure 1. Soil water potential at 8-inch depth during the 1993 irrigation season as measured by tensiometers and by GMS (AgriMet) in a Nyssa silt loam planted to alfalfa. The field was irrigated on June 19, July 10, August 3, and August 13. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

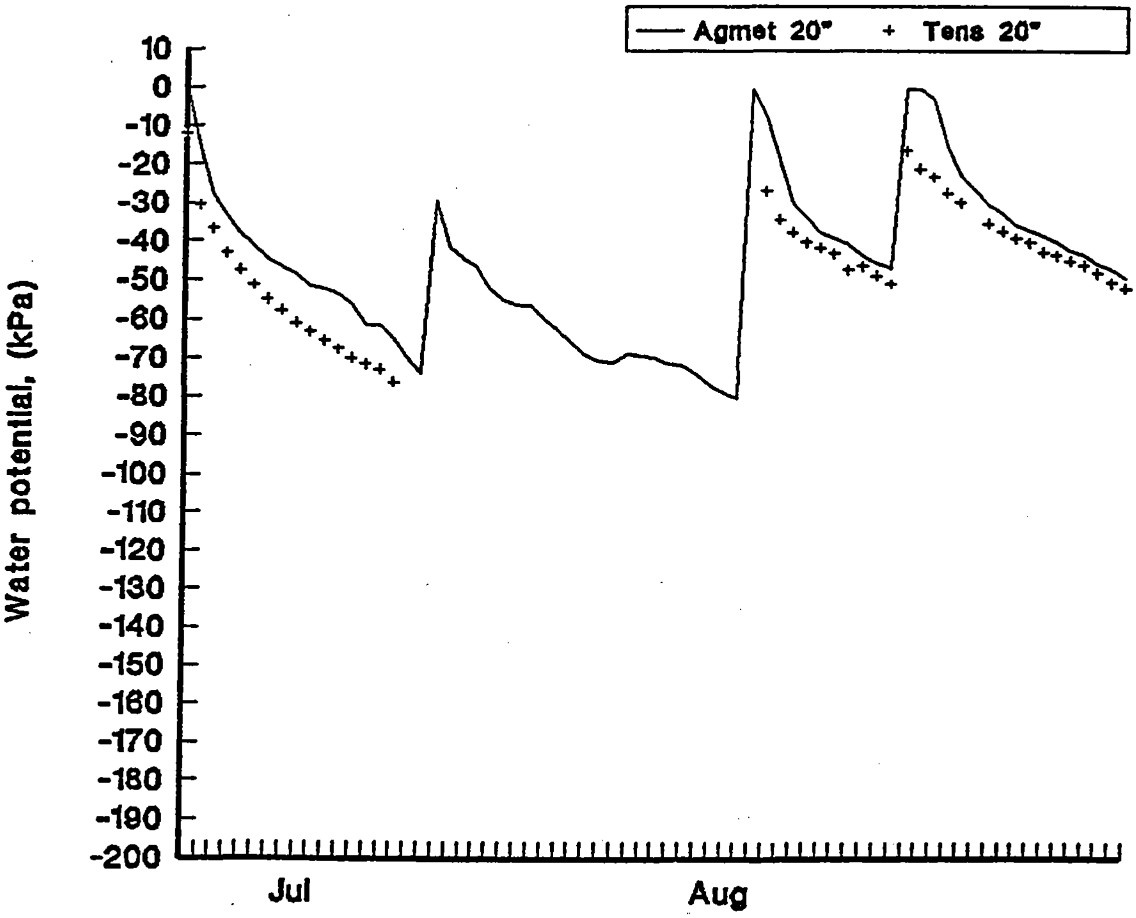


Figure 2. Soil water potential at 20-inch depth during the 1993 irrigation season measured by tensiometers and by GMS (AgriMet) in a Nyssa silt loam planted to alfalfa. The field was irrigated on June 19, July 10, August 3, and August 13. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

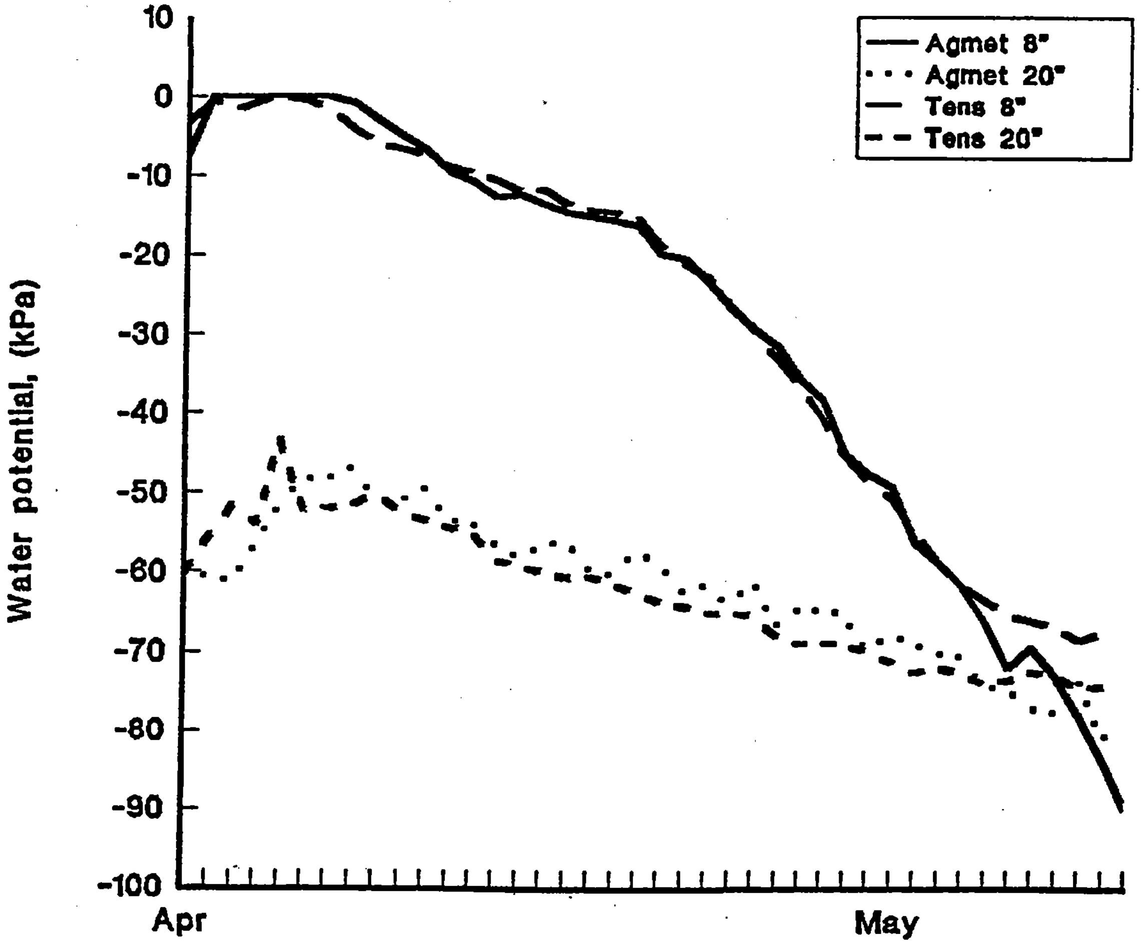


Figure 3. Spring soil water potential measured either by tensiometers or by GMS (AgriMet) were comparable. Due to repeated small rains, the upper part of the soil profile became saturated then dried slowly while the soil at 20-inch depth remained relatively dry. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

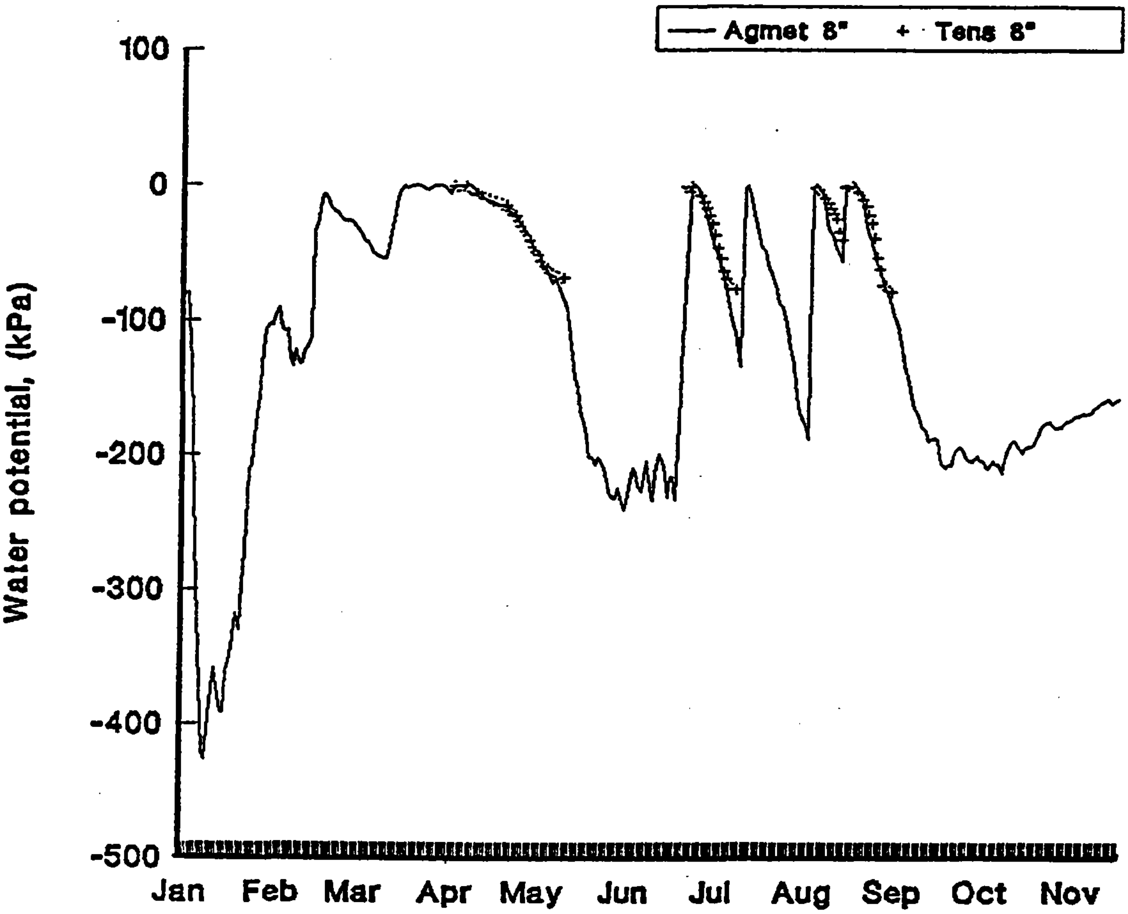


Figure 4. Soil water potential at 8-inch depth measured by tensiometers and by GMS (AgriMet) in a Nyssa silt loam planted to alfalfa, 1993. Peaks in soil water during February through early June are related to snow melt and rainfall, while peaks during July and August are related to irrigation. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

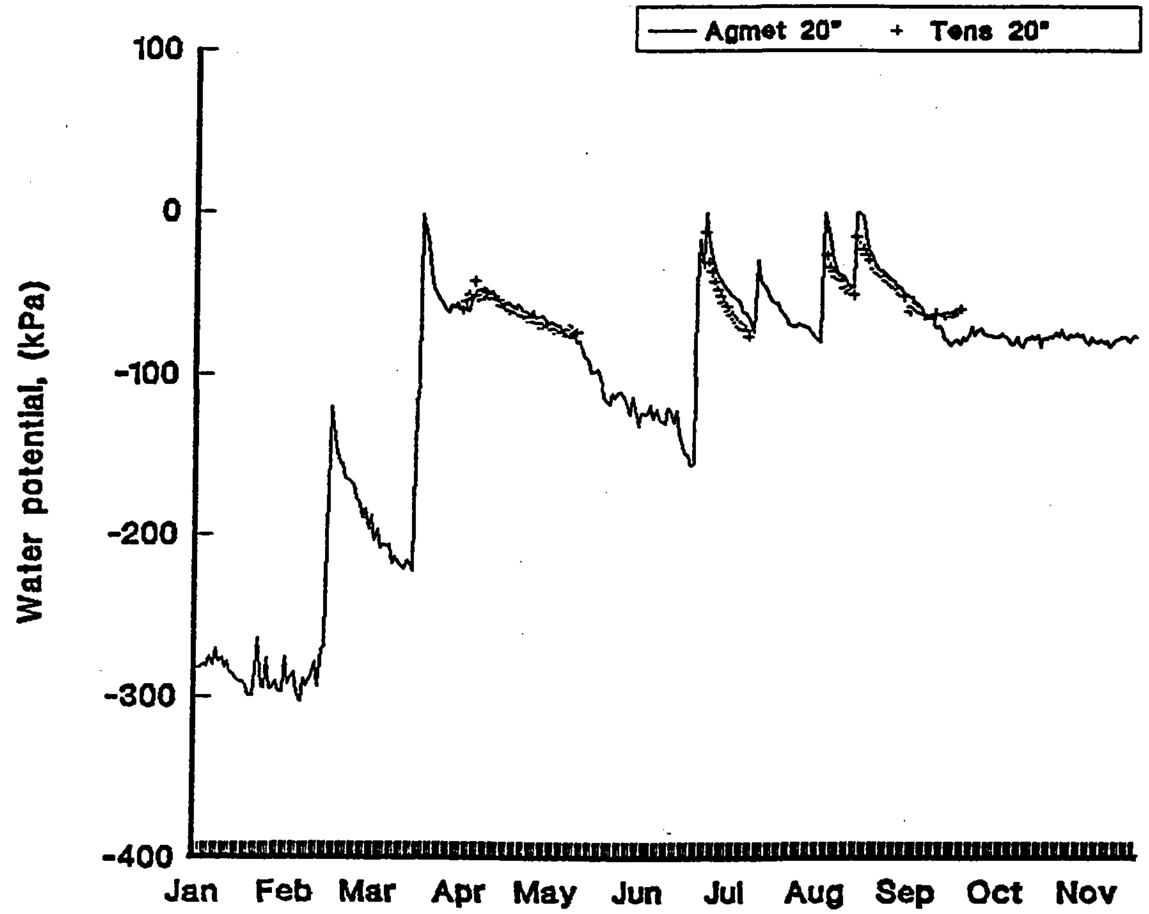


Figure 5. Soil water potential at 20-inch depth measured by tensiometers and by GMS (AgriMet) in a Nyssa silt loam planted to alfalfa, 1993. Peaks in soil water during February through early June are related to snow melt and rainfall, while peaks during July and August are related to irrigation. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

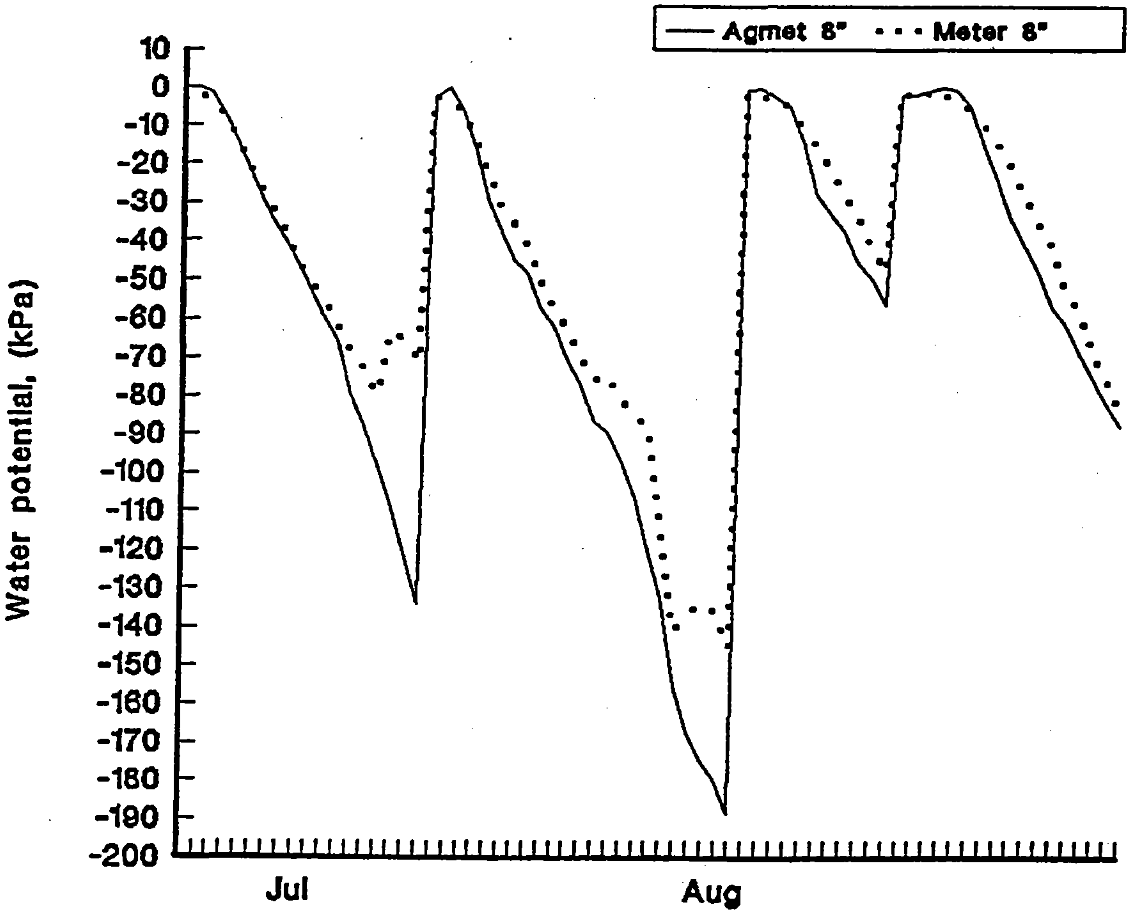


Figure 6. GMS soil water potential at 8-inch depth during the 1993 irrigation season as measured by AgriMet and by a 30 KTCD meter. The field was a Nyssa silt loam planted to alfalfa and irrigated on June 19, July 10, August 3, and August 13. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

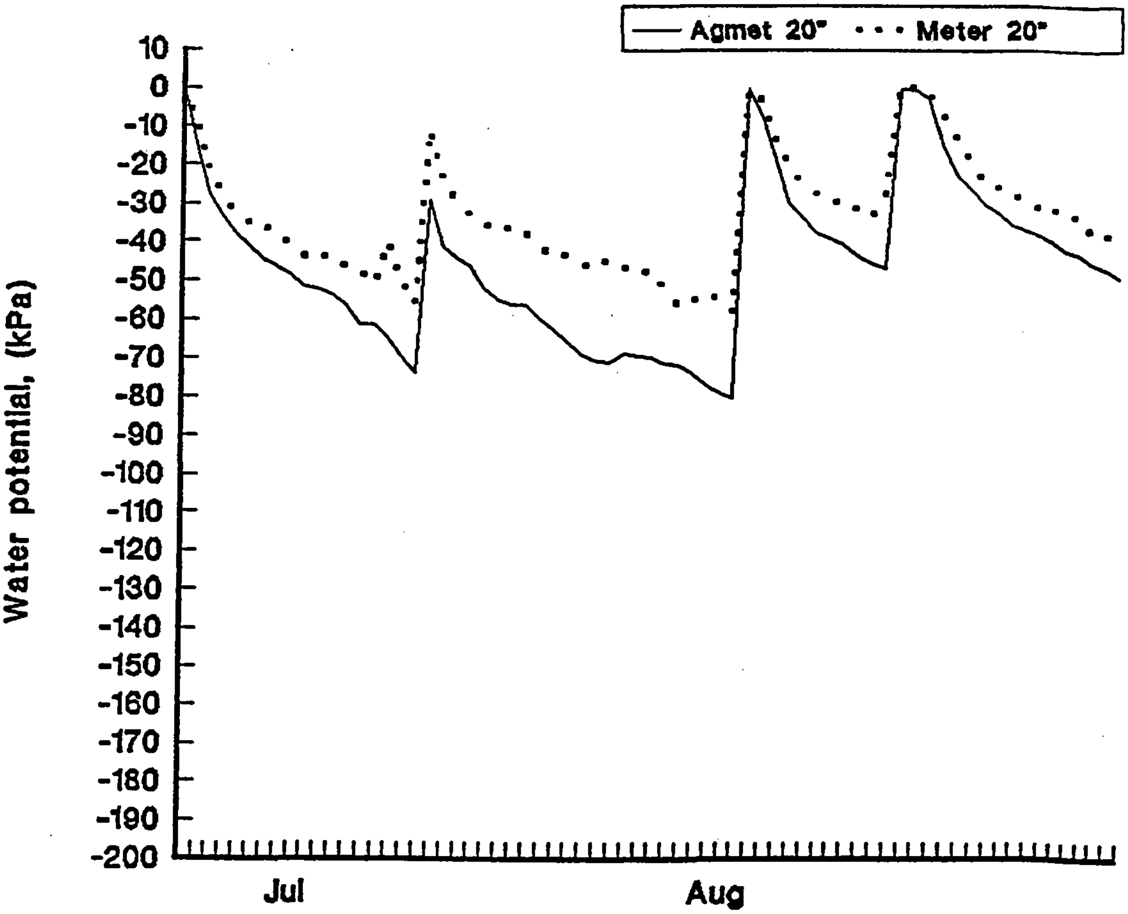


Figure 7. GMS soil water potential at 20-inch depth during the 1993 irrigation season as measured by AgriMet and by a 30 KTCD meter. The field was a Nyssa silt loam planted to alfalfa and irrigated on June 19, July 10, August 3, and August 13. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

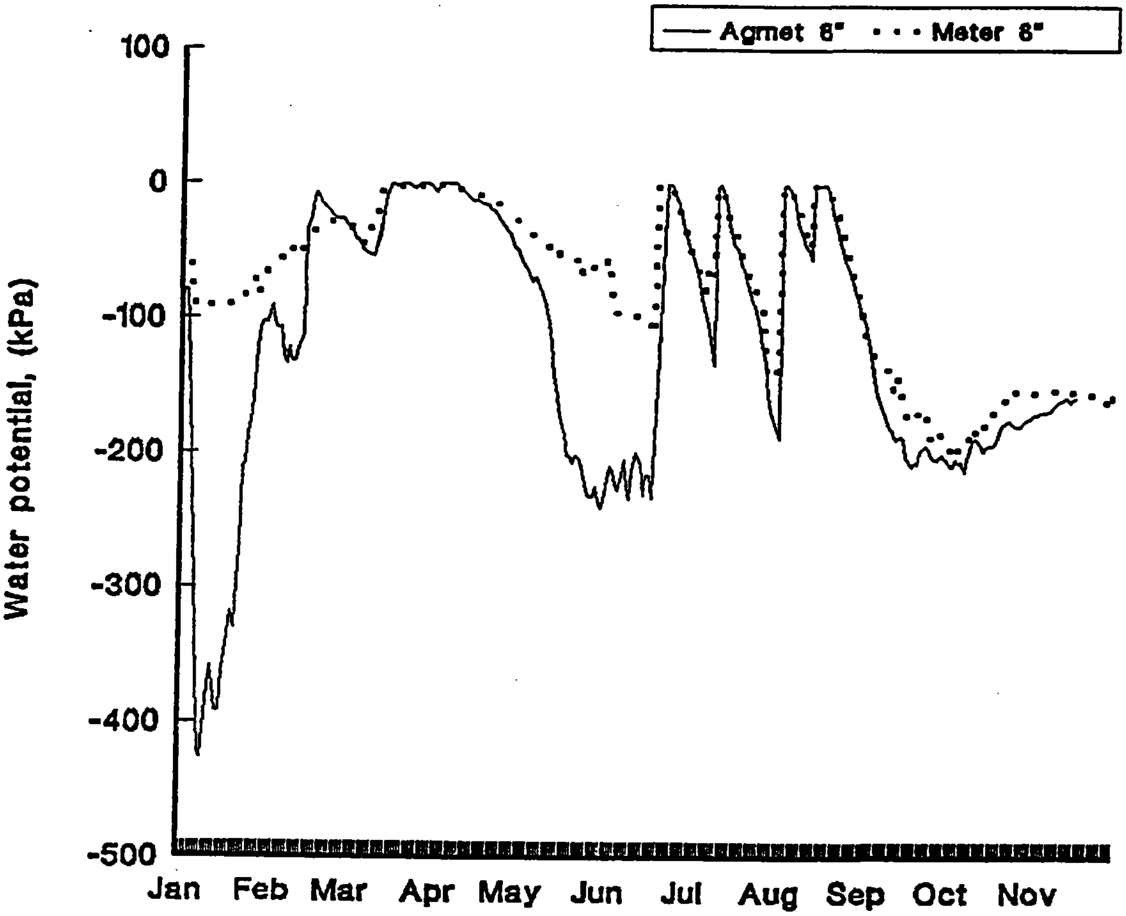


Figure 8. GMS soil water potential at 8-inch depth during 1993 as measured by AgriMet and a 30 KTCD meter. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

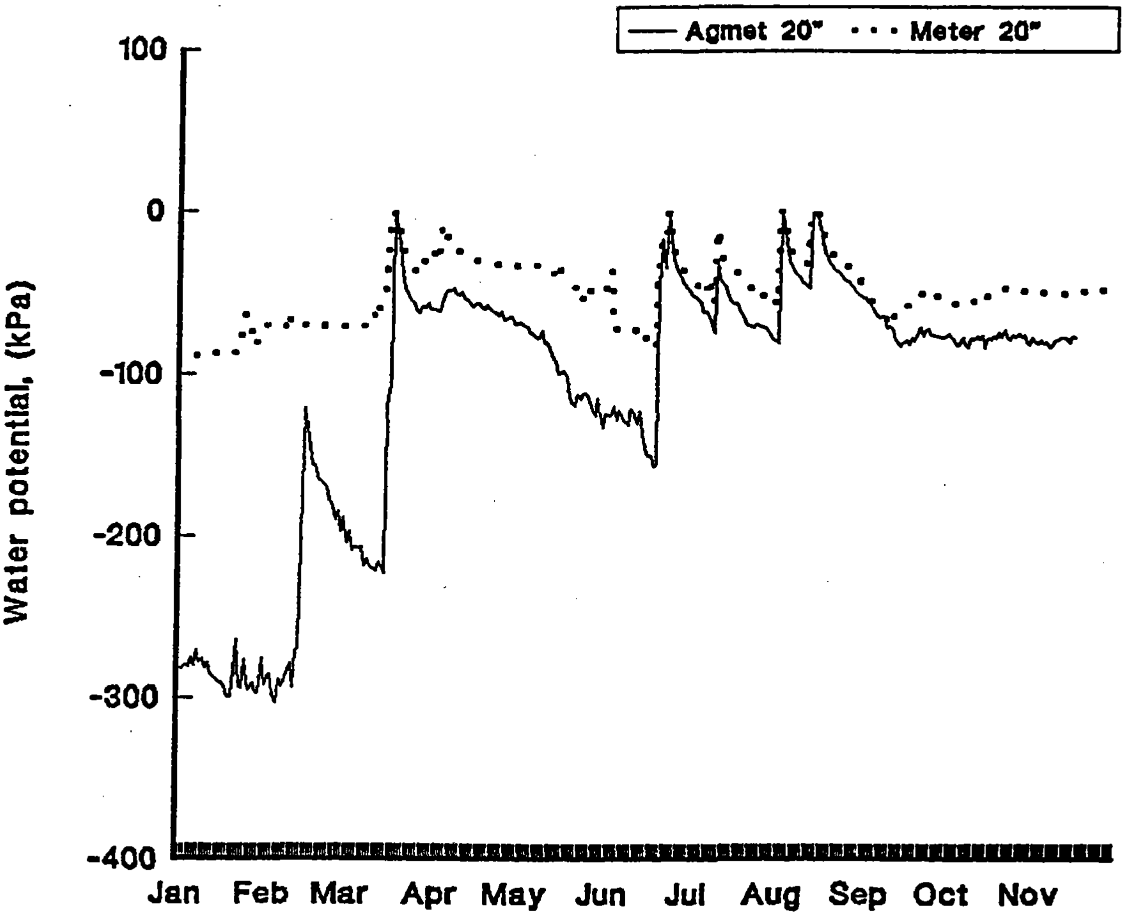


Figure 9. GMS soil water potential at 20-inch depth during 1993 as measured by AgriMet and by a 30 KTCD meter. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

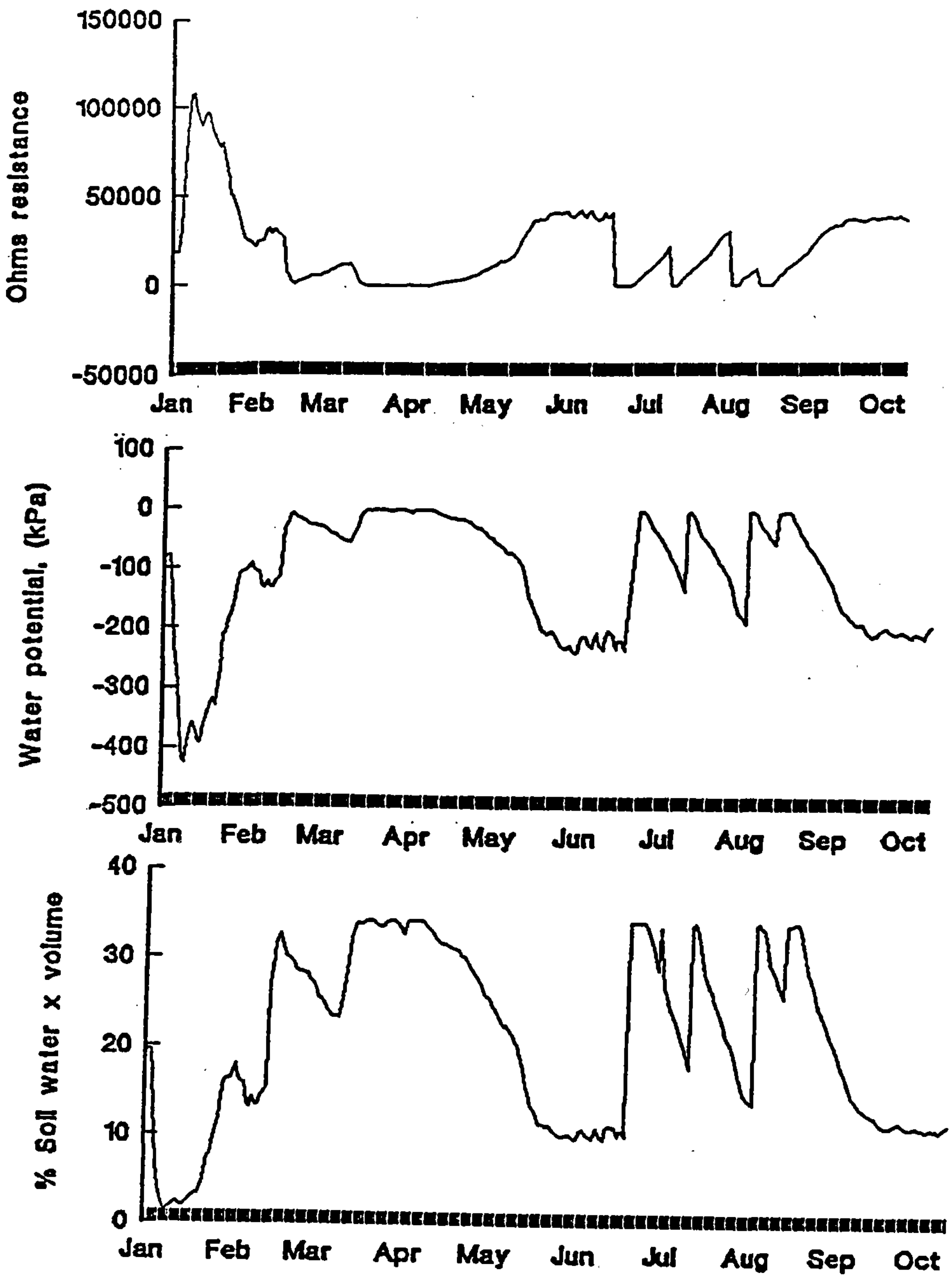


Figure 10. Granular matrix sensor (Watermark Model 200SSX) data collected by AgriMet and interpreted as resistance (kohms), soil water potential (kPa), and soil volumetric water content at the 8-inch depth. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

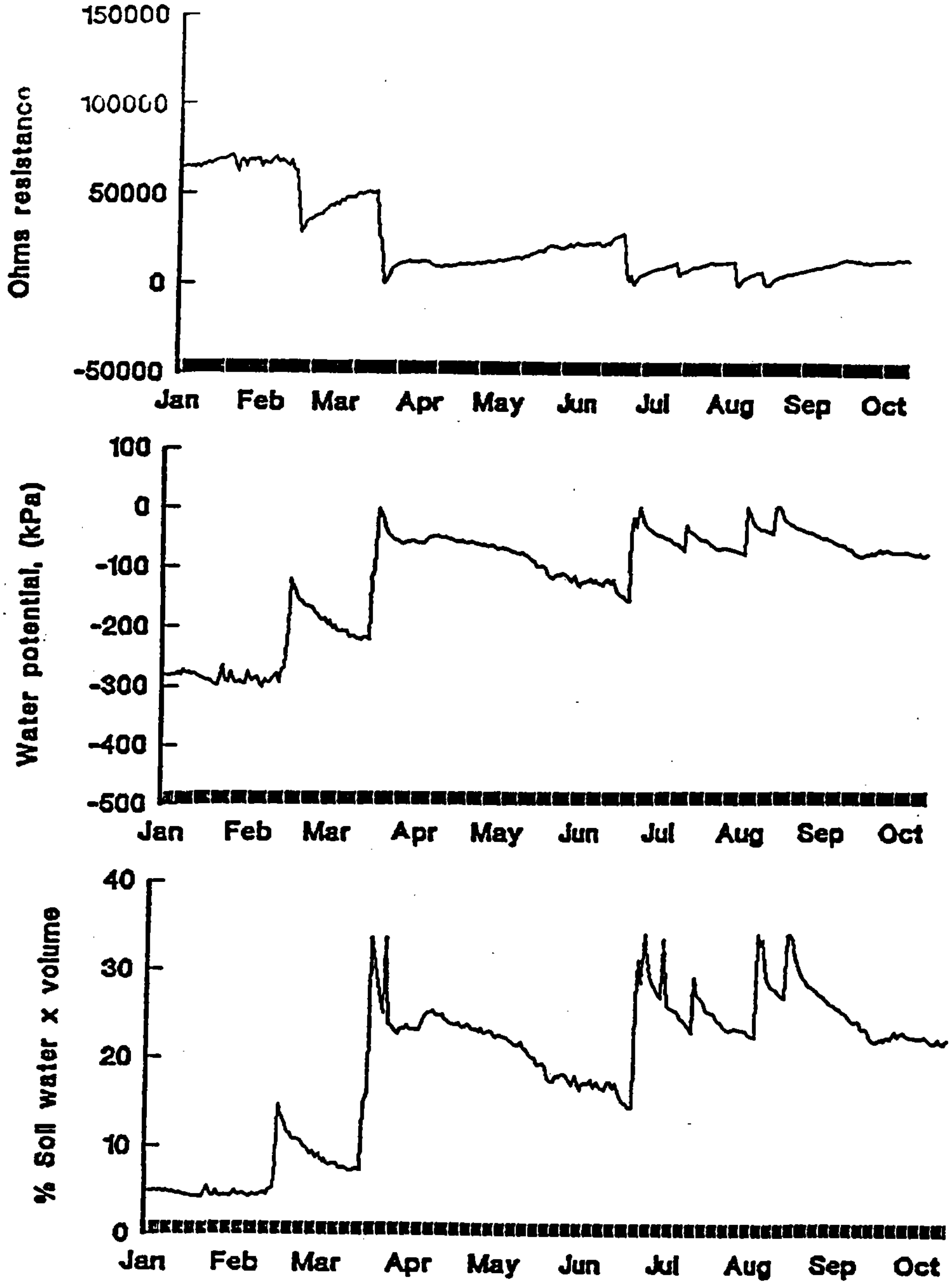


Figure 11. Granular matrix sensor (Watermark Model 200SSX) data collected by AgriMet and interpreted as resistance (kohms), soil water potential (kPa), and soil volumetric water content at the 20-inch depth. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

IMPROVED IRRIGATION EFFICIENCY AND REDUCTION IN SEDIMENT LOSS BY MECHANICAL FURROW MULCHING WHEAT

C.C. Shock[1], L.D. Saunders[1], B.M. Shock[1], J. H. Hobson[2], M. J. English[3],
and R.W. Mittelstadt[3]
[1]Malheur Experiment Station and
[3]Bioresource Engineering
Oregon State University
[1]Ontario, Oregon
[2]Hobson Manufacturing Inc.
Ontario, OR

Abstract

Treasure spring wheat was grown on sloping ground with and without mechanically applied furrow mulching. Furrow mulching used 800 lb/ac of wheat straw. Mulched and non-mulched furrows were irrigated five times during the season receiving 483 and 19.0 and 40.9 ac-in of irrigation water, respectively. For non-mulched furrows, infiltration totaled 13.0 ac-in, while runoff constituted 27.9 ac-in or 68.1 percent of applied water. For mulched furrows, infiltration totaled 13.2 ac-in, while runoff constituted 5.8 ac-in or 30.5 percent. Average sediment yield was reduced from 49.4 tons/ac to 2.2 tons/ac with furrow mulching. Grain yield increased by 15.7 bu/ac with furrow mulching, from 96.0 to 111.7 bu/ac.

Introduction

The use of surface irrigation on sloping ground has resulted in substantial loss of topsoil in Malheur County over the last 50 years. Wheat straw can be used to mulch irrigation furrows, with potential short term and long term benefits. Often the potential economic advantages of a change in crop management practices is evaluated on a one-year basis. In the present study, irrigation furrows in field plots have received 0 or 800 lbs/ac of wheat straw each of four successive years. While furrow mulching led to increased potato quality in 1990, there was no yield improvement. Repeated furrow mulching led to increased yields of onions in 1991 and sugar beets in 1992. Would yield advantages continue with spring wheat in 1993?

Consistently, furrow mulching has provided reduced sediment loss and improved irrigation efficiency for the row crops. Would sediment losses and improvements in irrigation efficiency and sediment loss be less with wheat that is planted perpendicular to the direction of the irrigation furrows and covers much more of the soil surface?

Procedures

A 1.3 acre field of Nyssa silt loam with 3 percent slope was planted April 24, 1993, to Treasure spring wheat at 115 lb/ac. Planting was delayed by late snow melt (March 17) and wet spring soil conditions. Planting followed fall chisel plowing and fall planting of winter wheat. Winter wheat stands failed due to carry-over residual herbicide damage from herbicide applications to the preceding sugar beet crop.

Irrigation furrows were bedded out at 27 inch spacing and the field was divided into 27 plots, each 235 feet long, arranged lengthwise down the field. At random, 12 of the plots were designated in 1990 as non-mulched plots and 12 were designated as furrow-mulched plots. The other three plots have been planted as borders. Potatoes, onions, sugar beets, and spring wheat have been planted in successive years (1990, 1991, 1992, and 1993) with and without mechanical furrow mulching of wheat straw at 800 lb/ac each year (Hobson Mulching System, Hobson Manufacturing Inc., Ontario, OR). Gated pipe was arranged so that all 24 plots were irrigated during the same irrigation set but the duration of irrigation in the non-mulched furrows was longer due to slower water infiltration rate.

Regardless of furrow treatment, only every other furrow was irrigated at about 2 gallons/min during each irrigation. During successive irrigations, only the previously irrigated furrows were irrigated, a pattern which we have called "alternate" furrow irrigation.

On June 10 Bronate was applied using a tractor mounted spray boom at 1 qt/ac to control broadleaf weeds. On July 9 DiSyston EC was applied at 0.5 lb ai/ac by air to control aphids.

Water and Sediment Measurement

Onset of water inflow and water outflow, and measurements of water inflow rate, water outflow rate, and sediment yield were recorded during each irrigation. Water inflow rates were recorded and outflow rates were recorded for one of the two irrigated furrows in each plot. For each water outflow rate reading, a one-liter sample was placed in an Imhoff cone and allowed to settle for 15 minutes. Sediment content in the water, y in g/l, was found to be related to the Imhoff cone reading after 15 minutes (x) by the equation $y = 1.015x$ with $r^2 = 0.98$ and $p < 0.0001$.

Composite water samples were collected in 5-gallon buckets to obtain sediment samples for nutrient analysis during each irrigation. Sediment will be analyzed for nitrate-N, ammonium-N, total N, phosphate-P, and total P.

Total inflow, outflow, infiltration, and sediment loss were integrated from field measurements using a Lotus Improv program "InfilCal 5.0" (Shock and Shock, 1993).

During all five irrigations, inflow water samples and outflow water samples were collected from every plot. The collection time of the water was recorded and composite water samples were made in proportion to the water inflow or outflow volume calculated by InfilCal 5.0. Composite water samples will be analyzed for nitrate-N, ammonium-N, and phosphate-P. Net nutrient losses are to be calculated.

Results and Discussion

The crop developed slowly and did not need irrigation until May. The crop was irrigated on May 17, June 17, July 2, July 15, and July 28. Irrigation durations were shorter for the plots with furrow mulching. The long delays between irrigations and late crop maturity were caused by cooler and wetter than normal weather. Crop evapotranspiration or consumptive use was only 19.6 ac-in for the season.

The duration of irrigation with and without furrow mulching was managed to provide the crop about the same amount of water infiltration (19.4, 24.5, 12.7, 12.3, and 12 hours, respectively, with straw compared to 48, 47, 28, 24.3, and 25.5 hours, respectively, without straw). The irrigation duration in the non-mulched plots was prolonged so that water infiltration, 13.2 ac-in, closely matched the infiltration in the plots with furrow mulching, 13.0 ac-in, (Table 1). To match infiltration in the furrow mulched plots required that more than twice as much water be applied to the non-mulched plots. Irrigation water infiltration plus rainfall was less than crop consumptive use in both strawed and non-strawed plots (Table 2).

Without straw mulch, on average, 68.1 percent of the applied water was lost as runoff; whereas, with straw mulch the loss was 30.5 percent (Table 3). Water lost was not wasted, since it entered the feeder ditch for irrigating the next successive field down hill.

Sediment loss averaged 20 times higher in the non-strawed furrows than in the mulched furrows (Table 4). The high rate of sediment loss without straw mulch 49.4 t/ac was surprising given the soil cover provided by wheat.

Furrow mulching increased wheat yields from 96.0 to 111.7 bu/ac (Table 5). Since the increase in wheat yield was not directly related to relative water stress, increased yield may be due to cumulative improved soil conditions resulting from four years of continuous furrow mulching. Grain bushel weight and harvest index were not significantly changed by furrow mulching.

Table 1. Total water applied, runoff, and infiltration during five furrow irrigations with and without furrow mulching on spring wheat. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	By irrigation					
	1	2	3	4	5	Total
No straw mulch	------- ac-in[§] ------					
Water applied	12.3	10.8	6.4	5.5	5.9	40.9
Runoff	9.0	7.6	3.6	3.6	4.1	27.9
Infiltration	3.3	3.2	2.8	1.9	1.8	13.0
Furrow mulching						
Water applied	4.4	5.8	3.0	3.1	2.7	19.0
Runoff	1.5	1.6	0.9	1.0	0.8	5.8
Infiltration	2.9	4.2	2.1	2.1	1.9	13.2
Comparison by mulching						
LSD(0.05) Water applied	0.3	0.4	0.1	0.4	0.1	0.7
LSD(0.05) Runoff	0.7	0.5	0.6	0.4	0.5	1.6
LSD(0.05) Infiltration	ns	0.5	0.8	0.2	ns	ns

[§] 1 ac-in = 25.4 mm

Table 2. Water budget for furrow irrigated spring wheat with and without furrow mulching. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	No mulch	Furrow mulch
	ac-in	
Infiltration of applied water	13.0	13.2
Rainfall (planting to harvest)	3.2	3.2
Total supply for crop	16.2	16.4
Consumptive use (ET_c)	19.6	19.6
Estimated deep percolation	0	0
Estimated net extraction	3.4	3.2

Table 3. Percent runoff of applied water during five furrow irrigations with furrow mulching of spring wheat. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Percent runoff by irrigation					
	1	2	3	4	5	Total
	---------- % -------					
No straw mulch	74.8	72.3	56.4	64.4	69.8	68.1
Furrow mulching	32.7	28.5	30.3	30.8	31.5	30.5
LSD(0.05)	11.4	7.0	11.7	7.2	12.6	6.4

Table 4. Sediment yield in runoff water during five furrow irrigations with and without furrow mulching of spring wheat. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Sediment yield by irrigation					
	1	2	3	4	5	Total
	------- t/ac[$] --------					
No straw mulch	15.1	12.7	10.0	4.7	6.9	49.4
Furrow mulching	0.5	0.04	1.3	0.07	0.3	2.2
LSD(0.05)	3.0	1.5	6.3	1.1	2.9	15.0
[$] 1 t/ac = 2.24 Mg/ha						

Table 5. Yield, grain weight, and harvest index of soft white spring wheat grown with and without furrow mulching. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Grain yield	Bushel weight	Harvest index
	bu/ac	lb/bu	0 to 1
No straw mulch	96.0	60.5	.518
Furrow mulching	111.7	60.7	.506
LSD(0.05)	8.1	ns	ns

BROADLEAF WEED CONTROL IN WINTER WHEAT AND SPRING BARLEY

Charles E. Stanger and Joey Ishida
Malheur Experiment Station
Oregon State University
Ontario, Oregon, 1993

Purpose

Banvel herbicide was evaluated for tolerance by winter wheat and spring barley, and for broadleaf weed control when applied by itself and in tank-mix combination with other herbicides commonly used for broadleaf weed control in cereal grain crops.

Methods and Materials

Stephens winter wheat was planted on October 28, 1992 after potatoes were harvested. The field was moldboard plowed and the seedbed was prepared after plowing with a roller-packer harrow. Steptoe of barley was planted April 17, following a 1992 planting of sweet corn. After sweet corn harvest the crop residue finely chopped with a steel-tooth flail beater. The field was moldboard plowed and left until spring. Both fields were fertilized with 60 pounds of N and 100 pounds of phosphate as a broadcast application before plowing. Soils in both fields were silt loam texture, with a pH of 7.3, and 1.2 to 1.5 percent organic matter.

Herbicide treatments were applied to wheat at different stages of growth. Applications to wheat 4 inches tall with two or three tillers were applied on April 23. Applications to wheat 8-13 inches tall (1-2 joints) were applied on May 17. Applications to spring barley were also applied on May 17. The barley plants had three to four leaves with one or two tillers.

All herbicide treatments were applied using a single bicycle wheel plot sprayer with a 9 foot boom. Teejet fan nozzles, size 8002, were spaced 10 inches apart on the boom and the herbicides were applied as broadcast double over-lap applications. Spray pressure was 42 psi and water was applied at a volume of 33.4 gallons per acre. Refer to data tables for spraying conditions when treatments were applied.

Each treatment was replicated three times and each replication randomized within blocks using a complete block experimental design. Individual plot size was 9 x 35 feet.

Wheat and barley were harvested for yield from all treatments using a Wintersteiger plot harvester. A 4 foot strip was cut from the center of each plot. The harvested grain was cleaned and weighed. Yields in bushels per acre were calculated from plot weights. Yields were analyzed to obtain statistical data.

Results

Slight stunting and leaf distortion occurred to wheat in all plots treated with herbicides applied in tank-mix combinations with Banvel (Table 1). Higher injury ratings occurred when Banvel was tank-mixed with the higher rates of Ally, Amber, Express, or Finesse. Less injury occurred when Banvel was applied tank-mixed with 2, 4-D, MCPA, Buctril, Express, and Harmony Extra. The higher wheat yields were obtained with Banvel tank-mixed with 2, 4-D, MCPA, Buctril, and the lower rates of Ally and Harmony Extra. Wheat yields were less when Banvel was tank-mixed with Amber, Express, and Finesse. Excellent broadleaf weed control and wheat yields were obtained with Bronate. Wheat yields were increased when wild oats were controlled with Tiller and Hoelon (Table 4).

Less foliar injury was recorded with those herbicide treatments applied to winter wheat 8-12 inches tall and jointing (Table 2).

Spring barley was sensitive and foliar injury occurred from Banvel tank-mixes that included Amber, MCPA, and Ally (Table 3). Barley grain yields were slightly less when Banvel was tank-mixed with Ally at the higher rate (0.004 lbs ai/ac), and with the tank-mix including Ally + MCPA + X-77 applied at 0.004 + 0.25 lbs ai/ac with X-77 at 0.25 percent v/v rate. The highest barley yield was obtained in the untreated check, though not significantly greater than most treated plots (Table 6).

Broadleaf weed species included tansy mustard, kochia, lambsquarters, pigweed, sow thistle, tumbling mustard, and hairy nightshade. All broadleaf weeds were controlled with the broadleaf herbicide treatments. Wild oats were controlled with Hoelon and Tiller in both wheat and barley. Barley was more tolerant to Tiller than Hoelon, but grain yields were not reduced by either herbicide when compared to grain yields in the untreated check.

Table 1. Percent weed control and crop injury ratings from herbicide treatments applied to winter wheat 4 inches tall with two or three tillers. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Herbicide	Rate	Visual			Percent weed control																	
		Crop Injury			Wild oats			Tansey mustard			Kochia			Lambsquarters			Pigweed			H. Nightshade		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	lbs ai/ac	---- % ----			------------ % ------------																	
Banvel + 2,4-D	0.125 + 0.38	5	10	10	10	10	15	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + MCPA	0.125 + 0.38	15	10	10	15	15	15	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Buctril	0.125 + 0.25	5	10	5	10	10	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Ally	0.125 + 0.004	5	5	5	10	15	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Ally	0.125 + 0.002	5	10	5	15	20	15	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Amber	0.125 + 0.014	15	15	15	10	20	15	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Amber	0.125 + 0.007	20	15	15	20	15	20	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Express	0.125 + 0.008	15	10	15	15	10	15	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Express	0.125 + 0.004	15	10	10	10	5	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Finesse	0.125 + 0.014	20	15	20	15	15	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Finesse	0.125 + 0.007	10	10	10	15	10	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Harmony Extra	0.0125 + 0.014	5	10	5	15	10	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Harmony Extra	0.125 + 0.007	5	5	5	10	5	15	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Bronate	0.5	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Tiller	0.08	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Hoelon	1.0	0	0	0	100	100	100	25	15	15	20	25	20	20	15	20	15	20	20	20	20	15
Check	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

X-77 added at the rate of 0.25% of the water volume with tank-mix including Ally, Amber, Express, Finesse and Harmony Extra.

Trial Information:

Wheat variety: Stephens Previous Crop: Potatoes
Soil texture: Owyhee silt loam Soil pH: 7.3 Soil OM: 1.2%
Irrigation method: furrow, first irrigation applied on May 12th.
Herbicides applied: April 23rd Wheat growth 2-3 tillers, 4" tall
Spraying conditions: air temperature (69°F), skies (overcast), wind (calm)
Sprayer: single bicycle wheel, 9 ft boom, broadcast double overlap, 8002 teejet fan nozzle, 42 psi, 33.4 gal water/ac.
Weed size at time of spraying: 1. Tansy mustard, tumbling mustard, prickly lettuce were with two inch rosettes. Kochia, lambsquarters and hairy nightshade were cotyledon. Wild oats were 3-4 leaf.
Plot size: 9 x 35 ft Replications: 3 Harvest date: August 12th

Table 2. Percent weed control and crop injury ratings from herbicides applied to winter wheat 8-12 inches tall and jointing. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Herbicide	Rate	Visual Crop Injury			Percent weed control																	
					Wild oats			Tansey mustard			Kochia			Lambsquarters			Pigweed			H. Nightshade		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	--- lbs ai/ac ---	----- % -----			---------- % ----------																	
Banvel + Harmony Extra	1/8 + 0.016	15	10	15	15	20	20	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Buctril	1/8 + 0.5	15	15	10	20	15	20	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Bronate Gel	0.75	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Bronate	0.75	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Harmony Extra	0.016	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Bronate + Harmony Extra	0.375 + 0.016	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Bronate + Harmony Extra	0.5 + 0.016	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
MCPA Ester + Harmony Extra	0.25 + 0.016	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2,4-D Amine + Harmony Extra	0.25 + 0.016	0	0	0	5	10	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2,4-D Amine	1.0	0	0	0	10	10	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2,4-D Amine + Banvel	0.5 + 0.125	10	15	15	15	20	20	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Bronate	1.0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2,4-D + Harmony Extra	0.25 + 0.016	0	0	0	5	10	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2,4-D Amine	0.5	0	0	0	5	10	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
2,4-D Amine + Banvel	0.5 + 0.125	15	15	15	20	20	20	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Check	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
X-77 added at the rate of 0.25% of the water volume with all Harmony Extra treatments.																						

<u>Trial information:</u>

Wheat variety: Stephens Previous crop: Potatoes
Soil texture: Owyhee silt loam Soil pH: 7.3 Soil OM: 1.2%
Irrigation method: rill or furrow, first irrigation applied on May 12th.
Herbicides applied on May 17th Wheat height: 8-12 inches (1-2 joints)
Spraying conditions: air temperature (85°F), wind (calm), soil moisture (85% available), skies (clear)
Sprayer: single bicycle wheel, 9 ft boom, double overlap broadcast, 8002 teejet nozzles, 42 psi, 33.4 gal water/ac
Weed size at time of spraying: 1-Tansy mustard (8-10"), kochia (3-6"), lambsquarters (3-4"), H. Nightshade (2-3"), pigweed (2-3"), and wild oats (2-3 tillers).
Plot size: 9 x 35 ft Replications: 3 Harvested August 11 and 12th

Table 3. Percent weed control and crop injury ratings from herbicide treatments applied to spring planted barley with three-four leaves and one-two tillers. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Herbicide	Rate	Visual Crop Injury			Percent weed control																	
					Wild oats			Tansey mustard			Kochia			Lambsquarters			Pigweed			H. Nightshade		
		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
	-- lbs ai/ac --	------ % -----			---------- % ----------																	
Banvel	0.094	15	15	15	10	10	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Amber	0.013	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Amber	0.094 + 0.013	40	40	40	10	10	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
MCPA Amine	0.25	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + MCPA	0.094 + 0.25	20	20	20	15	10	10	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Amber + MCPA	0.094 + 0.25	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Ally	0.004	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Banvel + Ally	0.094 + 0.004	35	25	20	30	30	25	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Ally + MCPA	0.004 + 0.25	0	10	5	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Bronate	0.75	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Bronate	1.0	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Bronate + Harmony Extra	0.375 + 0.016	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Bronate + Harmony Extra	0.5 + 0.016	0	0	0	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Tiller	0.08	0	0	0	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Hoelon	1.0	10	5	5	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Check	-	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

X-77 added at rate of 0.25% of the water volume with tank-mix including Amber, Ally and Harmony Extra.

<u>Trial Information:</u>

Barley variety: Steptoe Previous crop: Sweet corn

Soil texture: Owyhee silt loam Soil pH: 7.3 Soil OM: 1.5

Irrigation method: furrow

Herbicide applied on May 17th. Barley was previously irrigated on May 12th.

Barley growth at time of application: 3-4 leaves, 1-2 tiller

Spraying conditions: air temperature (85°F), wind (calm), soil moisture (85%), skies (clear)

Sprayer: single bicycle wheel, 9 ft boom, broadcast double overlap, 8002 teejet fan nozzle, 42 psi, 33.4 gal water/ac

All weeds were small at time of spraying, 1-2 inches in height and across rosette. Oats were in the 3-4 leaf stage of growth. Plot size: 9 x 35 ft Replications: 3

Table 4. Wheat yields with herbicide applied at two to three tillers. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Herbicides	Rate	Grain yield							
		R_1	R_2	R_3	$\bar{X}$	R_1	R_2	R_3	$\bar{X}$
	lbs ai/ac	--------- lb/plot ---------				------ bu/ac ------			
Banvel + 2,4-D	0.125 + 0.38	27.98	22.52	29.83	26.78	144.9	166.6	154.5	138.7
Banvel + MCPA	0.125 + 0.38	23.11	26.82	26.59	25.51	119.7	138.9	137.7	132.1
Banvel + Buctril	0.125 + 0.25	29.49	24.19	28.80	27.59	152.7	125.3	149.2	142.4
Banvel + Ally + X-77	0.125 + 0.004 + 0.25%	27.66	20.59	23.24	23.83	143.3	106.7	120.4	123.4
Banvel + Ally + X-77	0.125 + 0.002 + 0.25%	27.21	26.57	27.63	27.14	140.9	137.6	143.1	140.6
Banvel + Amber + X-77	0.125 + 0.014 + 0.25%	22.55	26.02	25.07	24.55	116.8	134.8	129.8	127.2
Banvel + Amber + X-77	0.125 + 0.007 + 0.25%	23.03	21.04	20.96	21.68	119.3	109.0	108.6	112.3
Banvel + Express + X-77	0.125 + 0.008 + 0.25%	20.51	20.27	23.30	21.39	106.2	105.0	120.7	110.6
Banvel + Express + X-77	0.125 + 0.004 + 0.25%	21.07	20.90	22.13	21.37	109.1	108.3	114.6	110.7
Banvel + Finesse + X-77	0.125 + 0.014 + 0.25%	21.71	22.22	22.05	21.99	112.5	115.1	114.2	113.9
Banvel + Finesse + X-77	0.125 + 0.007 + 0.25%	27.08	18.81	22.91	22.93	140.2	97.5	118.7	118.8
Banvel + Harmony Extra + X-77	0.125 + 0.014 + 0.25%	29.42	26.05	29.75	28.41	152.4	134.9	154.1	147.2
Banvel + Harmony Extra + X-77	0.125 + 0.007 + 0.25%	28.46	20.86	23.45	24.26	147.4	108.0	121.5	125.6
Bronate	0.5	30.93	30.68	28.80	30.14	160.2	158.9	149.2	156.1
Tiller	0.08	34.54	31.68	33.39	33.20	178.9	164.1	172.9	172.0
Hoelon	1.0	32.59	32.59	26.32	30.50	168.8	168.8	136.3	158.0
Check	0	28.35	21.46	23.33	24.38	146.8	111.2	120.9	126.3

Overall Mean 132.7
LSD (0.05) 20.1
CV (S/mean) 9.09

Table 5. Wheat yields with herbicide late applications one-two joints. Malheur Experiment Station, Oregon State University, Ontario Oregon, 1993.

Herbicides	Rate	Grain yield							
		R_1	R_2	R_3	$\overline{X}$	R_1	R_2	R_3	$\overline{X}$
	lbs ai/ac	------ lb/plot ------				------- bu/ac -------			
Banvel + Harmony Extra	0.125 + 0.016	24.47	21.28	27.15	24.30	126.8	110.2	140.6	125.9
Banvel + Bromoxynil	0.125 + 0.5	21.34	24.53	25.33	23.70	110.5	127.1	131.2	122.9
Bronate Gel	0.75	27.77	27.06	28.84	27.89	143.8	140.2	149.4	144.5
Bronate	0.75	27.55	28.56	25.49	27.20	142.7	147.9	132.0	140.9
Harmony Extra + X-77	0.016 + 0.25%	24.30	23.00	29.23	25.51	125.9	119.1	151.4	132.1
Bronate + Harmony Extra + X-77	0.375 + 0.016 + 0.25%	22.71	28.48	20.88	24.02	117.6	147.5	108.2	124.4
Bronate + Harmony Extra + X-77	0.5 + 0.016 + 0.25%	20.96	23.67	20.25	21.63	108.6	122.6	104.9	112.0
MCPA Ester + Harmony Extra + X-77	0.25 + 0.016 + 0.25%	20.86	21.39	22.65	21.63	108.0	110.8	117.3	112.1
2,4-D Amine + Harmony Extra + X-77	0.25 + 0.016 + 0.25%	25.50	25.91	20.47	23.96	132.1	134.2	106.1	124.1
2,4-D Amine	1.0	21.46	22.05	21.05	21.52	111.2	114.2	109.0	111.5
2,4-D Amine + Banvel	0.5 + .0125	21.37	25.28	21.79	22.81	110.7	130.9	112.9	118.2
Bronate	1.0	26.93	27.92	25.87	26.91	139.5	144.6	134.0	139.4
2,4-D Amine + Harmony Extra + X-77	0.25 + 0.016 + 0.25%	28.47	26.71	25.23	26.80	147.5	138.9	130.7	139.0
2,4-D Amine	0.5	25.16	26.51	28.11	26.59	130.3	137.3	145.6	137.8
2,4-D Amine + Banvel	0.5 + 0.125	29.40	23.07	23.59	25.35	152.3	119.6	112.2	131.3
Check	-	27.29	24.09	19.76	23.71	141.4	124.8	102.4	122.8

Overall mean 127.4
LSD (0.05) 21.7
CV (S/mean) 10.38

Table 6. Yields of spring barley following herbicide applications. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Herbicides	Rate	Grain yield							
		R_1	R_2	R_3	$\bar{X}$	R_1	R_2	R_3	$\bar{X}$
	---- lbs ai/ac ----	------ lb/plot -------				--------- bu/ac ---------			
Banvel	0.094	18.23	18.05	16.83	17.70	157.5	155.9	145.4	153.0
Amber + X-77	0.013 + 0.25%	17.81	17.43	17.34	17.53	153.9	150.6	149.8	151.4
Banvel + Amber + X-77	0.094 + 0.013 + 0.25%	17.64	17.84	18.15	17.88	152.4	154.1	156.8	154.5
MCPA Amine	0.25	17.52	16.16	19.02	17.57	151.4	139.6	164.3	151.8
Banvel + MCPA Amine	0.094 + 0.25	18.93	17.27	19.17	18.46	163.5	149.2	165.6	159.4
Amber + MCPA Amine + X-77	0.013 + 0.25 + 0.25%	17.27	18.15	17.57	17.66	149.2	156.8	151.8	152.6
Ally + X-77	0.004 + 0.25%	17.64	18.06	18.05	17.92	152.4	156	155.9	154.8
Banvel + Alley	0.094 + 0.004 + 0.25%	16.21	17.53	16.75	16.83	140.0	151.5	144.7	145.4
Ally + MCPA + X-77	0.004 + 0.25 + 0.25%	17.31	18.01	16.45	17.26	149.6	155.6	142.1	149.1
Bronate	0.75	17.98	19.35	17.45	18.26	155.4	167.2	150.8	157.8
Bronate	1.0	19.53	17.69	19.06	18.76	168.7	152.8	164.7	162.1
Bronate + Harmony Extra + X-77	0.375 + 0.016 + 0.25	18.89	19.22	16.57	18.23	163.2	166.1	143.2	157.5
Bronate + Harmony Extra + X-77	0.5 + 0.016 + 0.25	19.40	16.26	17.42	17.69	167.6	140.5	150.5	152.9
Tiller	0.08	18.32	19.41	18.82	18.85	158.3	167.7	162.6	162.9
Hoelon	1.0	16.16	18.57	17.97	17.57	161.4	160.4	155.3	151.8
Check	-	18.68	18.85	19.78	19.10	161.4	162.9	170.9	165.1

Overall mean 155.1
LSD (0.05) 13.8
CV (S/mean) 5.34

ALTERNATE AND ALTERNATING FURROW IRRIGATION OF SMALL GRAIN AS LOW COST OPTIONS TO IMPROVE IRRIGATION EFFICIENCY AND REDUCE NITRATE LEACHING

Clinton C. Shock, J. Mike Barnum, and Alan R. Mitchell
Malheur Experiment Station and Central Oregon Agricultural Research Center
Oregon State University

Introduction

The use of furrow irrigation generally requires applications of irrigation water greatly in excess of the crop's consumptive water use (evapotranspiration, ET_c). Furrow irrigation requires relatively large water applications because much of the applied water leaves the field as runoff and is lost to the crop because the water percolates below the extent of the crop's root system. Deep percolation can carry soil nitrate towards groundwater. Many options suggested to growers to increase irrigation efficiency are dependent on changing irrigation systems to sprinkler or drip irrigation, both of which require large capital investments and considerable additional annual costs related to pumping and/or water filtration. Electrical power demands would be considerable for the widespread conversion of furrow irrigation to sprinkler irrigation. Surge irrigation can be used on certain furrow irrigated fields that are particularly well-shaped, but is not practical for all field layouts, especially if the field grade was planned without surge irrigation in mind. Perhaps low cost furrow irrigation management alternatives can be devised that can increase irrigation efficiency and reduce nitrate leaching without uneconomical or impractical capital outlays, and without large increases in annual operating expenses.

For the present discussion, let us use the term "every" furrow irrigation to describe conventional furrow irrigation where every furrow is irrigated during each irrigation. We define "alternate" furrow irrigation as an irrigation strategy where only every other furrow would be used to irrigate the crop and half the furrows would remain dry (not irrigated) all season. We define "alternating" furrow irrigation as an irrigation strategy where only every other furrow is irrigated, but on each successive irrigation the irrigated and dry furrows are switched.

Not all crops may be conducive to alternate furrow or alternating furrow irrigation. Small grains have extensive root systems and may be able to reach adequate moisture with only half of the furrows irrigated. With alternate or alternating furrow irrigation, less total water will be applied during each irrigation. We hypothesize that more of the water will move laterally below the soil surface under alternate and alternating furrow irrigation than under every furrow irrigation, thereby reducing deep percolation losses of water and reducing nitrate leaching.

Objectives

The objectives of this experiment were to compare conventional "every" furrow irrigation with "alternate" furrow irrigation and "alternating" furrow irrigation for water use efficiency and productivity for a crop of MacVicar winter wheat, and to evaluate crop nitrogen content at harvest and soil inorganic nitrogen (nitrate plus ammonium) under the three furrow irrigation strategies.

Procedures

A three-acre field of Owyhee silt loam with one-eighth-mile irrigation runs at the OSU Malheur Experiment Station, Ontario, Oregon had been planted to uniformly fertilized and irrigated onions in 1991. Following onion harvest, soil samples were taken in the top 2 feet of soil over the entire area. Zinc and sulfur as 65 lb/ac zinc sulfate and 100 lb/ac elemental sulfur were applied to correct soil nutrient shortages. MacVicar winter wheat was planted on October 3 at 130 lb/ac and the field was furrowed on 30-inch centers. On October 11, the soil was sampled in tiers at 100, 200, 300, 400, and 500 feet from the top of the field. Within each tier the soil was sampled at six locations in one foot increments to a depth of 6 feet. Samples within each tier at each depth increment were combined and analyzed for nitrate and ammonium. Soil sampling at 100, 300, and 500 feet was repeated at nine locations in each tier on March 26, 1992, at which time neutron probe access tubes were installed at these same tiers for each of nine irrigation plots.

The field was divided into nine plots, each consisting of eight furrows spaced 30 inches apart running the length of the field. The plots were organized as a completely randomized block design. Within each block every, alternate, and alternating furrow irrigation strategies were randomly assigned to one of the plots in the block. Irrigations were initiated April 16, May 8, and May 29. Water was applied to each irrigated furrow at approximately 6 gpm using constant pressure in a gated pipe and manually adjusted Aqua Control Nozzles. Water inflow to each furrow was measured during each irrigation using a 3.1 l catch can and a stopwatch. Total inflow to each plot during each irrigation was calculated by multiplying the sum of the inflow rate for each plot furrow times the irrigation duration. Water runoff was not measured. The elapsed time for water to advance 100, 300, and 500 feet was also recorded for each furrow. Neutron probe readings were taken before and after each irrigation to describe the distribution of applied water down the length of the field in each plot. Crop evapotranspiration was calculated using a modified Pennman equation and AgriMet weather station data.

Grids of 16 granular matrix sensors (GMS, Watermark Soil Moisture Sensor Model 200SS) were installed at 100, 300, and 500 feet down the irrigation run in furrows in each of the three furrow irrigation options. That is to say, there were three grids on three tiers with 16 sensors each (or a total of 3x3x16=144 sensors). Sensor resistance and soil temperature were recorded every five minutes during each irrigation and daily at 6 am between irrigations.

Weeds were controlled with a single application of 1 qt/ac of Bronate 4EC (2 lb ai/ac bromoxynil plus 2 lb ai/ac MCPA) in 30 gallons of water/ac on March 28. Insect control and nitrogen fertilization were not needed or used on the crop.

Grain was harvested on August 16 and 17 with a Wintersteiger Nurserymaster plot combine from three 95-feet increments of each plot centered at 100, 300, and 500 feet from the top of the field. Within each irrigation plot, four subplots (3.5 ft x 6 ft) were hand harvested and evaluated for biomass yield, and were threshed and oven dried to determine harvest index (the relative amount of grain and straw), and samples of the grain and straw were ground and analyzed for N content. Total crop N at harvest in lb N/ac was calculated for each tier of each plot using the combine harvested grain yield adjusted to 14 percent moisture, the grain to straw ratio from the hand harvested subplots, and the corresponding grain and straw N contents.

After harvest the soil in each plot was sampled to 6 feet in one-foot increments at each of the tiers (at 100, 300, and 500 feet). Soil samples were analyzed for nitrate and ammonium independently in each plot at each tier. Plant available-N in the soil profile at each soil sampling was calculated by using the analytical data for ammonium and nitrate, and the soil bulk density at the corresponding depth.

Results and Discussion

Neutron probe, water advance rate, and GMS data are not discussed here.

The MacVicar winter wheat grew rapidly due to favorably warm spring weather in 1992. During the first irrigation, problems were encountered with water breaking through beds between furrows. The first irrigation was stopped then restarted. The second and third irrigations were less problematic. The first irrigation would have been easier if the furrows had been deeper and more uniform. Furrow compaction before the first irrigation also could have helped reduce furrow breaking and accelerate water advancement. The field would have been more conducive to the experiment if it had been laser leveled in the recent past. In spite of the operational inconveniences, vastly more water was applied to the every furrow treatment than the alternate or alternating treatments (33.8 ac-in/ac compared to 17.3 and 17.1 ac-in/ac, respectively, Figure 1. Irrigations were ended when water in almost all furrows had advanced to the end of the field. Winter wheat evapotranspiration was 27.3 ac-in/ac in 1992. Application of water far lower than evapotranspiration was compensated for by extraction of residual soil water.

Grain yield was unaffected by irrigation treatment, averaging 125.8, 126.1, and 128.0 bu/ac for the every, alternate, and alternating furrow irrigation, respectively (Figure 2). Bushel weight was also unaffected by irrigation strategy.

At the beginning of the season, nitrate and ammonium in the top 2 feet of soil was substantially greater at the bottom of the irrigation run compared with the top of the field (Figure 3). Total nitrogen in the plant biomass at harvest was affected both by the irrigation strategy and position in the field (Figure 4). Wheat grain and straw near the top of the field contained less total N at harvest than wheat grain and straw grown further down along the irrigation furrows, consistent with the pattern of soil available-N in the field at planting. Winter wheat plant tops accumulated 180, 188, and 193 lb N/ac under every, alternate, and alternating furrow irrigation, respectively, (Figure 4, Table 2), without nitrogen fertilization. The increase in total plant N at harvest suggests that alternate and alternating furrow irrigation were less conducive to nitrate leaching than every furrow irrigation.

Post-harvest residual nitrate and ammonium in the soil was substantially different between every, alternate, and alternating furrow irrigation, respectively (Figure 5, Table 1). Greater residual nitrate and ammonium in the alternate and alternating furrow irrigation plots suggest that these strategies are less likely to leach nitrate during the season. Residual nitrate and ammonium were also strongly affected by the relative position sampled in the field, consistent with the greater amounts of nitrate and ammonium in the soil profile the previous fall. Leaching was reduced during 1992 with distance from the top of the field. Reduced water contact time during each irrigation with lower position in the irrigation run was related to reduced nitrate leaching closer to the bottom of the field. Further reductions in nitrate leaching were associated with the alternate and alternating furrow irrigation strategies.

Considering both wheat N content at harvest and residual plant available-N in the soil after harvest, much more nitrogen was accounted for at harvest in the alternate and alternating furrow irrigation plots than the every furrow irrigation plots at all three tiers measured (Figure 6). Decreases in soil inorganic nitrogen under every furrow irrigation in the post-harvest soil nitrate and ammonium were not compensated by differences occurring at the 2-6 foot depth, but actually were aggravated with depth, as would be expected if accentuated deep leaching occurred under every furrow irrigation.

Accounting of available-N, water N content, and plant N content suggest that a net of 100 to 200 lb N/ac was mineralized between the spring and post-harvest soil samples (Table 2). Alternate and alternating furrow irrigation allowed greater retention of available nitrogen, whereas available nitrogen was more apt to be lost where every furrow was irrigated.

Conclusions

1. Winter wheat was effectively irrigated using alternate and alternating furrow irrigation on Owyhee silt loam. The irrigation strategies had no effect on grain yield or grain test weight. Furrows and beds need to be carefully constructed so that beds retain their integrity, especially during the first irrigation in mellow, loose soil. Without careful bed preparation and furrow compaction, water can easily cut across beds into non-irrigated furrows.

2. Savings of applied water were nearly 50 percent under alternate and alternating furrow irrigation of MacVicar winter wheat on the one-eighth-mile runs used in this trial. No yield loss was associated with decreased water application.

3. Much less plant available-N was recovered from the soil post-harvest under every furrow irrigation compared with either alternate or alternating furrow irrigation, suggesting reduced nitrate leaching occurred under alternate and alternating furrow irrigation.

Figure 1. Acre-inches/acre of water applied to MacVicar winter wheat on one-eighth-mile long runs using every, alternate, and alternating furrow irrigations. Data are presented for the three successive irrigations that occurred in 1992. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

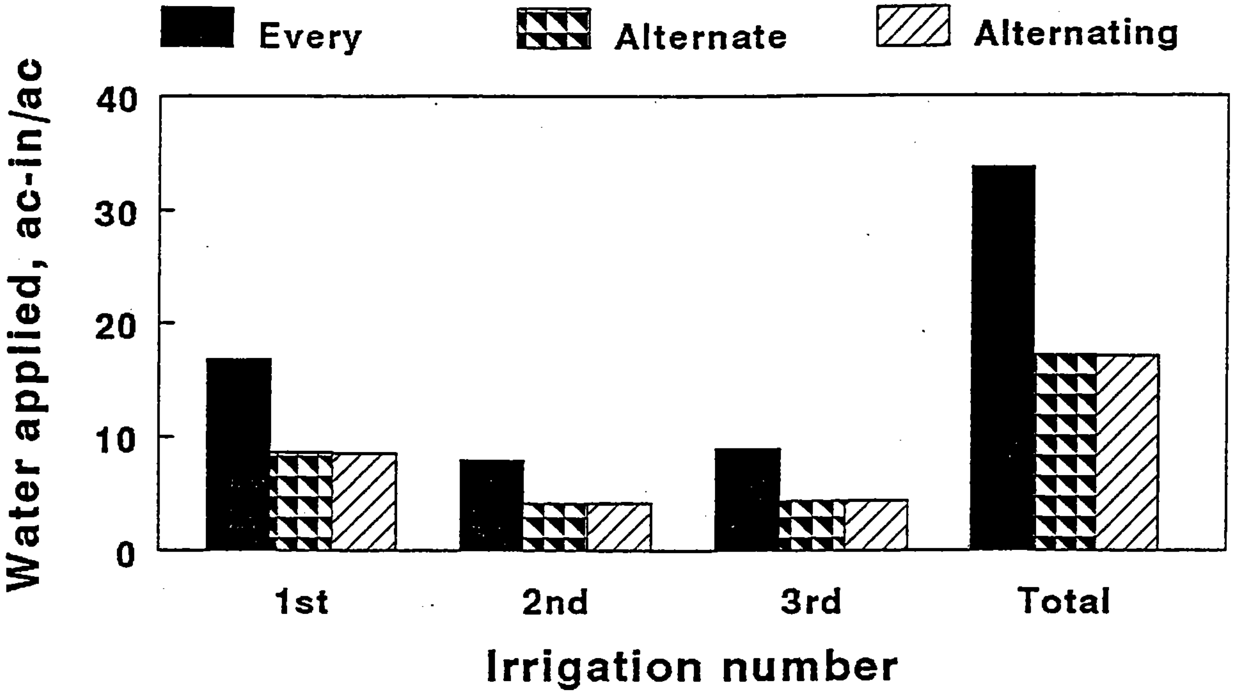
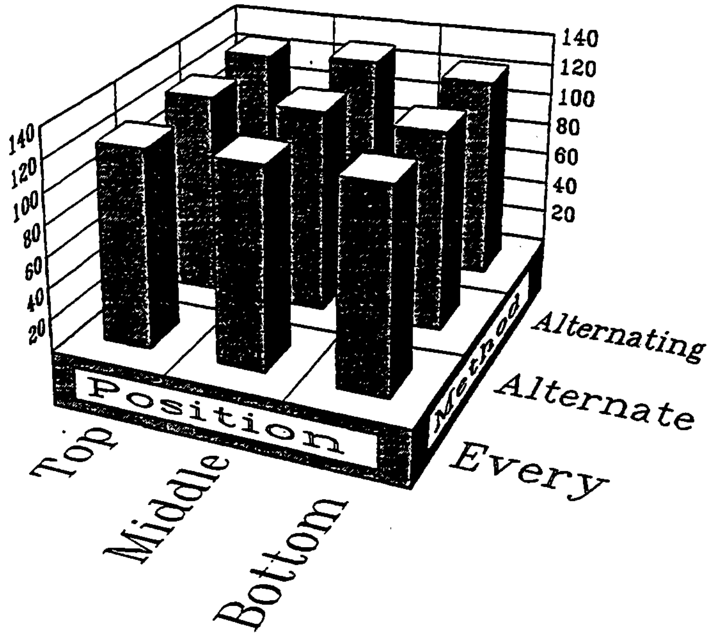


Figure 2. Grain yield in bushels per acre of MacVicar winter wheat was unaffected by three furrow irrigation strategies. Yields are reported at the top, middle, and bottom of the irrigation runs in 1992. Malheur Experiment Station, Oregon State University, Ontario, Oregon.



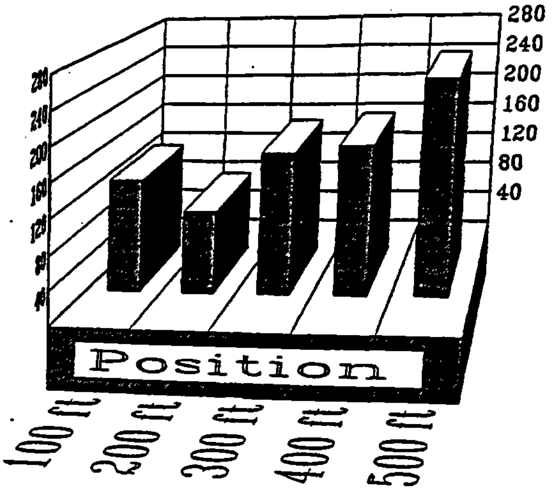


Figure 3. Distribution of soil inorganic N (nitrate plus ammonium in lb N/ac) down the length of the irrigation runs in the top 2 feet of soil prior to planting MacVicar winter wheat in the fall of 1991. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

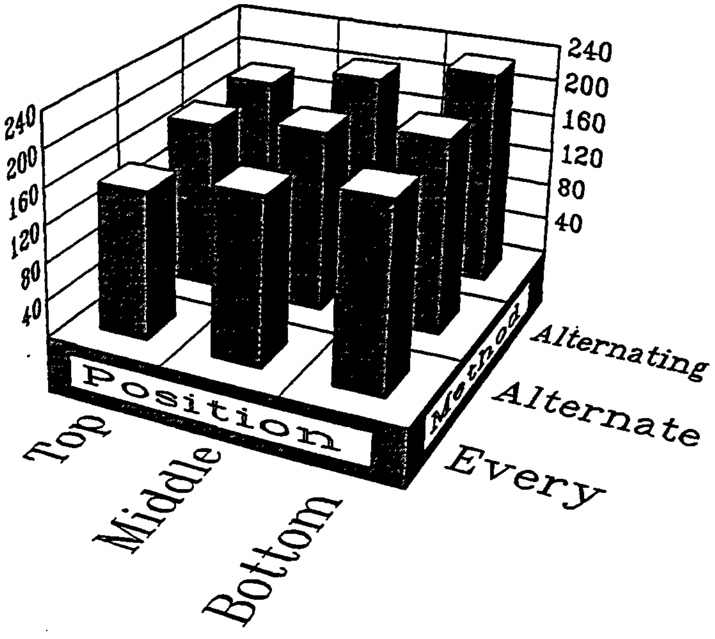


Figure 4. Nitrogen contained in the grain and straw of MacVicar winter wheat in lb N/ac as influenced by every, alternate, and alternating furrow irrigations. Nitrogen content was evaluated at the top, middle, and bottom of each irrigation run in 1992. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

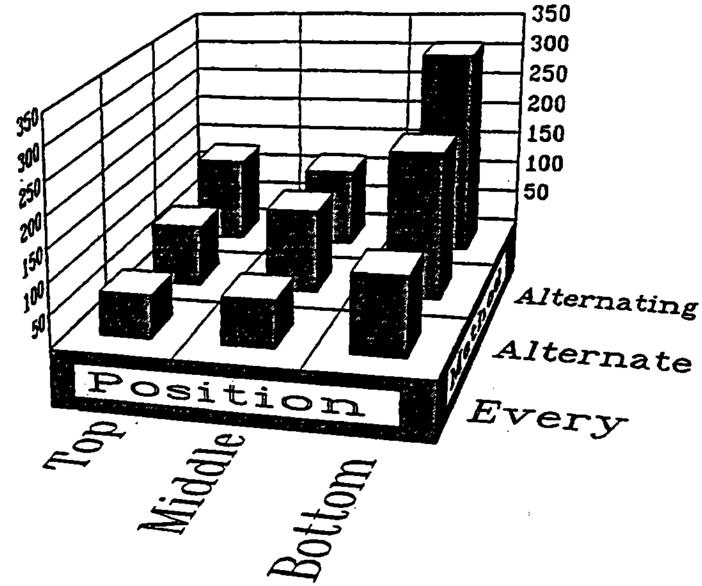


Figure 5. Residual soil inorganic N (nitrate plus ammonium in lb N/ac) in the top 2 feet of soil following the use of every, alternate, and alternating furrow irrigations, and the harvest of MacVicar winter wheat in 1992. Data are reported for the top, middle, and bottom of the irrigation run in 1992. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

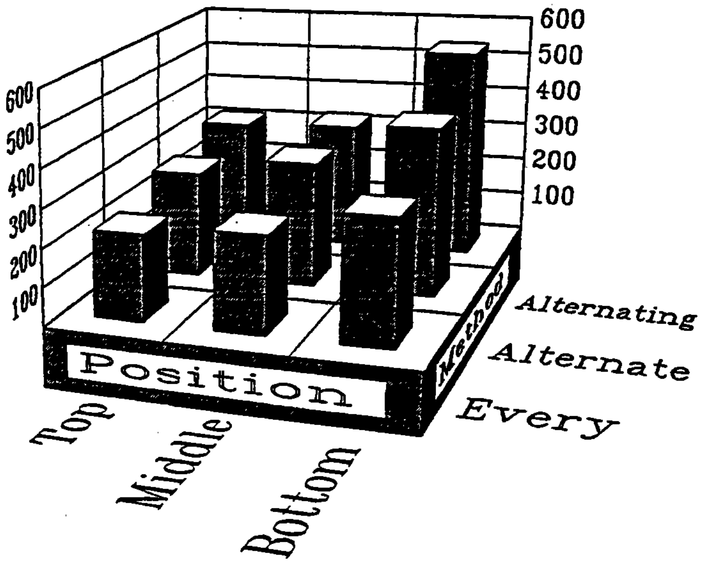


Figure 6. Total N recovered in the wheat plants at harvest plus the residual nitrate and ammonium in the top 2 feet of soil following every, alternate, and alternating furrow irrigations. Data are reported for the top, middle, and bottom of the irrigation run in 1992. Malheur Experiment Station, Oregon State University, Ontario, Oregon.

Table 1. Inorganic nitrogen (nitrate plus ammonium) in the soil profile to a depth of six feet at planting, before spring irrigation and after harvest following every, alternate, and alternating furrow irrigation. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1992.

Soil Depth	10/91 At planting	3/92 Before irrigation strategies			7/92 After irrigation strategies		
		Every	Alternate	Alternating	Every	Alternate	Alternating
feet	lb N/ac	---- lb N/ac ----			----- lb N/ac -----		
0-1	124.4	81.2	78.0	65.5	31.8	47.2	39.3
1-2	39.6	78.6	75.2	72.6	54.7	60.2	77.3
2-3	43.4	93.3	86.4	98.7	58.9	73.7	75.0
3-4	50.1	74.0	70.0	66.2	66.3	66.1	73.8
4-5	56.7	72.9	70.2	67.4	68.0	70.6	99.5
5-6	61.9	85.7	84.3	80.7	69.0	66.9	89.2
0-6'	376.1	486.0	464.2	451.0	348.7	384.8	454.1

Table 2. Effects of every, alternate, and alternating furrow irrigation on available nitrogen accounting in winter wheat and in the soil profile (0 to 6) feet between spring soil samples and post-harvest soil samples. Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1992.

Furrow irrigation strategy	Spring inorganic N in soil	Fertilizer N	Inorganic N in water	Total	Plant N at harvest	Post harvest inorganic N in soil	Total	Apparent N mineralization less N leaching
	------------------------- lb N/ac -------------------------							
Every	486.0	0	24.2	510.2	179.5	348.7	528.2	18.0
Alternate	464.2	0	12.4	476.6	188.4	384.8	576.4	99.8
Alternating	451.0	0	12.2	463.2	192.9	454.1	653.8	190.5

1993 OSU STATEWIDE AND MALHEUR SMALL GRAIN TRIALS

J. Mike Barnum
Malheur Experiment Station
Oregon State University
Ontario, Oregon

Purpose

The purpose of these trials is to evaluate the performance of newly released and commercially available small grain cultivars under local cultural practices and environmental conditions. Data obtained from these trials provide OSU extension personnel, industry representatives, and local producers with statistical information that can be utilized in recommending or choosing a cultivar for a specific area or situation.

Nine cereal grain evaluation trials were conducted at the Malheur Experiment Station during the 1992-93 crop year.

The OSU Statewide Winter Grains, Winter Feed Barley, Spring Grains, and Spring Barley trials were conducted as part of a statewide cereal evaluation program that is partially funded by the Oregon Grains Commission and the Oregon Wheat Commission. This statewide program is coordinated by OSU Extension Cereal Specialist, Dr. Russ Karow, Corvallis, Oregon.

The Malheur White Winter Wheat Trial is conducted every year. The purpose of the trial is to evaluate newly developed experimental or recently released commercially available soft white wheat cultivars and to compare their performance to those cultivars commonly being grown in the western Treasure Valley.

The OSU Advanced Line Soft White Winter Wheat and Spring Wheat trials were conducted to evaluate the performance of newly developed experimental lines under local conditions.

1993 marks the second year in which a Fall Planted Winter Emergence Spring Wheat Trial and a Fall Planted Spring Emergence Spring Wheat Trial have been conducted at the Malheur Experiment Station. The purpose of these trials is to develop a database that may be of help to local growers when faced with the decision of when to stop planting winter types and start planting spring types.

Procedure

All trials were planted in a randomized complete block design with three replications. All plots were 10 feet wide by 15 feet long. Each plot was planted on two 60-inch beds with seven rows on each bed. All trial nurseries were furrow irrigated. At maturity, harvest samples were collected from a 50 inch swath through the center of each plot. The harvest area for each plot was 62.51 sq. ft. (0.001435 acres). Following harvest all samples from the OSU Statewide trials were transported to the

OSU campus at Corvallis where each "harvester run" sample was cleaned with a Pelz seed cleaner and then processed. The "harvester run" samples from the Malheur and OSU Advanced Line trials were rough-cleaned with an aspirator cleaner and processed at the Malheur Experiment Station.

Winter Wheat, Winter Barley, and Fall Planted Spring Wheat Trials

Following the 1992 harvest of sweet corn, the field in which all of the winter cereal trials were grown was disked two ways, chisel plowed two ways, and floated twice. No preplant fertilizer was applied. The winter wheat nurseries, OSU Statewide, Malheur White Winter, and OSU Advanced Line trials, were planted on October 5, 1992. Because of a planter breakdown, the OSU Statewide Barley Trial and the two Malheur Fall Planted Spring Wheat trials were planted on October 8. All entries in the six trials were drilled, approximately 1 inch deep, into dry soil. The seeding rate for the OSU Statewide Winter Wheat Trial and the OSU Statewide Winter Barley Trial was 30 seeds per square foot. The seeding rate for the Malheur and OSU Advanced Line trials was approximately 120 pounds per acre. On October 13, a 12-hour post-plant, pre-emergence sprinkler irrigation was applied to the OSU Statewide Winter Wheat and Barley trials, the OSU Advanced Line Winter Wheat Trial, the Malheur White Winter Wheat Trial, and the Malheur Fall Planted Winter Emergence Spring Wheat Trial on October 13. Because it was desired that the Malheur Fall Planted Spring Emergence Spring Wheat Trial not emerge until the spring of 1993 this trial was not irrigated following planting.

Following the initiation of spring growth and the emergence of weed seedlings, a tank mix containing 0.375 lb ai/ac MCPA amine + 0.125 lb ai/ac dicamba (Banvel) in 20 gallons of water per acre was applied by ground-rig over the entire field on April 20, 1993. On April 21 all nine trials were top-dress fertilized with a broadcast application of N at 200 lbs/ac as 46-0-0. The first furrow irrigation was applied to all six trials on May 13. One additional furrow irrigation was applied to the barley trial on May 25. Two additional furrow irrigations were applied to the wheat trials on May 26 and June 16.

All six winter planted cereal trials were harvested on August 12 and 13, 1993.

Spring Wheat and Spring Barley Trials

In the fall of 1992 following the harvest of onions, the field in which the 1993 spring cereal trials were to be planted was chisel-plowed two ways, disked two ways, floated twice, bedded-up on 60-inch centers, and laid-by until the spring of 1993. On April 21 and 22, 1993, the pre-formed 60-inch beds were spiketooth harrowed, floated, and re-furrowed. All entries in the three trials were drilled, approximately 1 inch deep, into moist soil. The seeding rate for the OSU Statewide Spring Wheat Trial and the OSU Spring Barley Trial was 30 seeds per square foot. The seeding rate for the OSU Advanced Line trial was approximately 120 pounds per acre. Because laboratory test results from soil samples taken following the harvest of the 1992 onion crop indicated that adequate residual levels of N, P, K, and S were present within the top 2 feet of the soil profile, no preplant fertilizer was applied.

On May 22 two ground-rig applied herbicide treatments were sprayed over the entire field. The first application, to control broadleaf weeds, was a tank mix containing 0.375 lb ai/ac MCPA amine and 0.375 lb ai/ac bromoxynil (Bronate) + 0.125 lb ai/ac dicamba (Banvel) in 20 gallons of water per acre. The second application, to control seedling watergrass and wild oats, was 1.0 lb ai/ac diclofop (Hoelon) in 20 gallons of water per acre.

The first furrow irrigation was applied to all trials on May 23. Subsequently, three additional furrow irrigations were applied on June 16, July 2, and July 12.

On June 15, because laboratory test results from soil samples taken from the top foot of the soil profile following the first irrigation indicated a serious nitrogen deficiency, all three trials were top dressed with 110 pounds of N per acre as 46-0-0.

All three spring planted cereal trials were harvested on August 26, 1993.

Results and Discussion

1992-93 Winter Cereal Grain Trials

With the exception of the Malheur Fall Planted Spring Emergence Spring Wheat Trial, excellent seedling emergence and stand establishment was noted in all trials by late-October. The young seedlings were covered with snow cover for most of the winter. Except for the first seven days of January 1993, the field was blanketed with snow from November 12, 1992, through March 16, 1993. In the Malheur Fall Planted Spring Emergence Spring Wheat Trial emergence occurred in late March 1993 shortly after the snow pack had melted.

The OSU Statewide Winter Wheat Trial included 12 soft white winter wheat, one club wheat, and two winter triticale cultivars (Table 1). Yields ranged from 169.5 bu/ac for MacVicar to 133.3 bu/ac for Gene (OR 1993). The yields for both MacVicar and Hill 81 were significantly better than the yields for Malcolm and Stephens. Bushel weights for the wheat cultivars ranged from 63.1 pounds for Gene to 61.1 pounds for Stephens.

The average heading date (50 percent headed) for the nursery was May 27. Heading dates for wheat cultivars ranged from May 24 for Gene, to May 30 for Hill 81.

At maturity, plant heights within the common wheats ranged from 35.7 inches for MacVicar, to 31 inches for Daws and Gene. No lodging was observed within any entry in this trial.

The Malheur White Winter Wheat Trial included nine soft white winter wheats and one club wheat (Table 2). Yields ranged from 173.6 bu/ac for Malcolm to 145.1 bu/ac for the club Rhode (OR 1993). Yield differences between Malcolm and Basin were not significant. Bushel weights ranged from 60.5 pounds for Lewjain, to 58.7 pounds for Rod (WA 1992).

Table 1. OSU Statewide Winter Wheat Trial conducted at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Type	Yield	Test weight	Days to heading[1]	Plant height
		bu/ac	lbs/bu		inches
	Comm	150.7	61.1	146	33.0
Malcolm	Comm	152.7	62.5	146	34.7
MacVicar	Comm	169.5	61.7	147	35.7
Madsen	Comm	162.1	61.8	149	32.0
Hill 81	Comm	166.9	62.0	150	33.0
Rod	Comm	158.4	61.4	149	32.0
Daws	Comm	133.4	63.3	147	31.0
Rhode	Club	148.3	62.6	149	29.3
B7-702	Comm	159.4	61.8	146	33.7
W-301	Comm	152.7	61.4	146	34.3
Hoff	Comm	148.2	64.6	145	32.7
Gene	Comm	133.3	63.1	144	31.0
Whitman	Trit	142.9	56.7	143	41.0
Celia	Trit	152.4	60.4	145	37.7
Nugaines	Comm	157.5	62.7	149	33.7
Mean		152.6	61.8	147	33.6
$LSD_{(0.05)}$		13.3	1.0	1	2.3
CV (%)		5.0	1.0	1	4.0

[1] Calendar days from January 1 to 50% heading

The average heading date (50 percent headed) for the nursery was May 29. Heading dates ranged from May 26 for Stephens, MacVicar, and Malcolm, to June 2 for Lewjain.

At maturity, plant heights ranged from 40.7 inches for Eltan to 26.3 inches for Basin. No lodging was observed within any entry in this trial.

The OSU Advanced Line White Winter Wheat Trial included 15 soft white wheat cultivars (Table 3). Yields ranged from 178.5 bu/ac for ORFW-HS004 to 105.9 bu/ac for Kharkoff. The yield for Stephens (161.2 bu/ac) was significantly less than the yield for MacVicar (177.8 bu/ac). Bushel weights ranged from 60.4 pounds for Kharkoff to 57.9 pounds for ORFW-HS004.

The average heading date (50 percent headed) for the nursery was May 28. Heading dates ranged from May 26 to June 1.

At maturity, plant heights ranged from 53 inches for Kharkoff to 29 inches for OR870831. No lodging was observed within any entry in this trial.

Table 2. Malheur White Winter Wheat Trial conducted at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Type	Yield	Test weight	Moisture	Days to heading[1]	Plant height
		bu/ac	lbs/bu	%		inches
Stephens	Comm	162.2	59.1	11.3	146	33.0
MacVicar	Comm	166.9	59.4	11.5	146	35.3
Malcolm	Comm	173.6	59.4	12.2	146	35.0
Daws	Comm	159.0	59.0	12.2	149	37.3
Lewjain	Comm	161.9	60.5	11.4	153	33.3
Eltan	Comm	154.3	59.5	12.2	150	40.7
Rod	Comm	165.7	58.7	11.5	149	31.7
Cashup	Comm	150.5	59.5	12.2	149	32.7
Basin	Comm	157.3	59.3	11.1	149	26.3
Rhode	Club	145.1	60.4	11.7	149	27.7
Mean		159.7	59.5	11.7	149	33.3
$LSD_{(0.05)}$		16.8	0.7	NS	1.2	2.7
CV (%)		6.2	0.7	5.1	0.5	4.7

[1] Calendar days from January 1 to 50% heading

Both the Fall Planted Winter Emergence Spring Wheat Trial and the Fall Planted Spring Emergence Spring Wheat Trial contained eight spring wheat cultivars (Tables 4 and 5). The same five soft white spring wheats and three hard red spring wheats were included in each trial. All eight entries in the fall emergence nursery emerged in late October 1992. The young seedlings were buried under snow from mid-November 1992 through mid-March 1993. Some winter injury was observed in all entries. In the spring emergence nursery the newly germinated seedlings emerged shortly after snow melt in early March 1993.

In the winter emergence trial, yields ranged from 137.9 bu/ac for Treasure to 87.4 bu/ac for UT001723 (Table 4). The yields for Treasure and Owens were not significantly different. Bushel weights ranged from 61.8 pounds for Serra to 59.7 pounds for Wakanz.

The average heading date (50 percent headed) for the winter emergence nursery was May 22. Heading dates ranged from May 21 for Owens, Penawawa, and Serra, to May 24 for Wakanz.

At maturity, plant heights for the winter emergence trial entries ranged from 46 inches for UT002571 to 29.7 inches for Penawawa. No lodging was observed within any of the eight entries.

Table 3. OSU Advanced Line Soft White Winter Wheat Trial conducted at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Type	Yield	Test weight	Moisture	Days to heading[1]	Plant height
		bu/ac	lbs/bu	%		inches
Kharkoff	Comm	105.9	60.4	11.8	146	53
Nugaines	Comm	155.2	59.5	11.9	147	33
Stephens	Comm	161.2	58.9	11.4	146	32
MacVicar	Comm	177.8	58.3	11.7	147	35
ORFW-H5002	Comm	134.0	58.1	11.7	149	44
ORFW-B0004	Comm	167.2	58.8	12.1	152	34
ORFW-HS004	Comm	178.5	57.9	11.6	147	34
OR8500933H	Comm	165.4	58.5	11.7	146	33
OR8501048P	Comm	153.6	56.4	11.5	146	36
OR860303	Comm	161.3	60.2	11.9	146	31
OR851139	Comm	156.5	59.2	11.8	149	34
OR870012	Comm	176.4	58.9	11.5	149	35
OR870337	Comm	160.1	59.2	11.8	148	31
OR870831	Comm	153.9	60.3	11.8	146	29
OR880525	Comm	168.2	59.9	11.7	149	34
		158.3	59.0	11.7	148	35
$LSD_{(0.05)}$		14.6	1.0	0.6	1.8	1.9
CV (%)			1.0	3.2	0.7	3.2

[1] Calendar days from January 1 to 50% heading

In the spring emergence trial, yields ranged from a high of 160.8 bu/ac for Penawawa to a low of 105.9 bu/ac for UT001723 (Table 5). There was no significant difference in yield among the five soft white cultivars. Bushel weights ranged from a 62.2 pounds for Serra to 60.4 pounds for Bliss (ID 1983).

The average heading date (50 percent headed) for the spring emergence nursery was May 26. Heading dates ranged from May 25 for Penawawa to May 27 for Wakanz.

At maturity, plant heights for the spring emergence trial entries ranged from 48 inches for UT002571 to 30.7 inches for Penawawa. No lodging was observed within any of the eight entries.

The grain yields in the spring emergence trial were markedly better than yields from the same varieties planted in the winter emergence trial. Yield differences between the two trials may suggest that Treasure, Bliss, and Wakanz are more winter hardy than Owens and Penawawa. Grain yields for Owens and Penawawa were 28.7 and 41.1 percent less, respectively, in the fall emergence trial than in the spring emergence trial.

Yields for Treasure and Bliss were 11 and 12.5 percent less, respectively, in the fall emergence trial than in the spring emergence trial.

Table 4. Fall Planted Winter Emergence Spring Wheat Trial conducted at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Type	Yield	Test weight	Moisture	Days to heading[1]	Plant height
		bu/ac	lbs/bu	%		inches
Owens	SW	112.0	60.7	12.0	141	31.3
Penawawa	SW	94.7	60.4	11.6	141	29.7
Treasure	SW	137.6	60.1	12.0	142	32.3
Serra	HR	102.4	61.8	11.3	141	30.7
Bliss	SW	135.9	60.1	11.5	142	34.0
UT002571	HR	110.0	60.2	11.7	142	46.0
UT001723	HR	87.4	60.8	11.2	142	35.7
Wakanz	SW	126.7	59.7	11.6	144	32.0
Mean		113.3	60.5	11.6	142	34.0
$LSD_{(0.05)}$		23.7	1.7	0.6	0.7	1.9
CV (%)		12.1	1.6	3.1	0.3	3.2

[1] Calendar days from January 1 to 50% heading

Table 5. Winter Planted Spring Emergence Spring Wheat Trial conducted at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Type	Yield	Test weight	Moisture	Days to heading[1]	Plant height
		bu/ac	lbs/bu	%		inches
Owens	SW	157.2	61.3	11.4	146	34.7
Penawawa	SW	160.8	61.7	11.1	145	30.7
Treasure	SW	154.7	60.7	11.5	146	35.7
Serra	HR	152.4	62.2	11.2	146	32.0
Bliss	SW	155.4	60.4	11.3	146	38.0
UT002571	HR	116.5	62.0	11.4	146	48.0
UT001723	HR	105.9	61.7	11.3	146	40.0
Wakanz	SW	151.1	60.4	11.1	147	35.7
Mean		144.3	61.3	11.3	145.9	36.9
$LSD_{(0.05)}$		13.9	0.5	0.6	0.5	1.9
CV (%)		5.6	0.5	3.2	0.2	2.9

[1] Calendar days from January 1 to 50% heading

The OSU Statewide Winter Feed Barley Trial included 10 six-row feed barley entries (Table 6). Yields ranged from 8,348 lbs/ac for OR81019 to 6,684 lbs/ac for Kamiak. The average yield for the trial was 7,702 lbs/ac. Bushel weights ranged from 55.4 pounds for Kold (OR 1993) to 51.5 pounds for OR81019.

The average heading date (50 percent headed) for the nursery was May 24. Heading dates ranged from May 20 for Kamiak to May 27 for Hesk.

At maturity, plant height ranged from 33 inches for Kamiak to 27 inches for Hundred and AB-812. Lodging averaged approximately 30 percent for all entries.

Table 6. OSU Statewide Winter Feed Barley Trial conducted at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Type	Yield	Test weight	Maturity rating[1]	Days to heading[2]	Plant height
		lbs/ac	lbs/bu			inches
Steptoe	6 row	8273	53.8	1.7	142	32
Showin	6 row	8114	51.6	1.7	144	28
Hesk	6 row	7819	53.1	3.0	147	31
Kamiak	6 row	6684	54.9	1.3	140	33
Hundred	6 row	7859	51.6	1.0	144	27
Gwen	6 row	7605	53.3	2.3	142	31
Kold	6 row	7245	55.4	3.0	143	30
Boyer	6 row	7986	53.2	2.3	145	32
AB-812	6 row	7082	54.0	1.7	145	27
OR81019	6 row	8348	51.5	3.0	143	28
Mean		7702	53.2	2.1	144	30
$LSD_{(0.05)}$		NS	1.0	0.8	2	2
CV (%)		9	1	22	1	4

[1] 1 = early, 3 = late
[2] Calendar days from January 1 to 50% heading

1993 Spring Cereal Grain Trials

The OSU Statewide Spring Wheat Trial included 21 spring cultivars (Table 7). Yields for the soft white types ranged from 137.8 bu/ac for Centennial to 100.1 bu/ac for Penawawa. Yields for the hard red types ranged from 122.6 bu/ac for ID000420 to 91.7 for WB 926. The yield for the advanced line OR386306 hard white was significantly greater than the yield for Klasic. The yield for the triticale Victoria was significantly greater than the yields for Juan or Celia (OR 1993).

Table 7. OSU Statewide Spring Wheat Trial conducted at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Type	Yield	Test weight	Days to heading[1]	Plant height	Protein	Hardness[2]
		bu/ac	lbs/bu		inches	%	
Centennial	SW	137.8	61.8	169	29	10.5	22
Dirkwin	SW	112.5	59.1	172	31	10.2	21
Klasic	HW	62.1	61.1	167	18	12.1	42
Penawawa	SW	100.1	58.8	171	28	10.2	5
Treasure	SW	116.4	59.4	170	30	10.1	15
WB 926	HR	91.7	61.0	166	27	12.6	52
Calorwa	Club	102.5	59.9	168	26	10.4	5
Yecora Rojo	HR	97.2	60.2	166	21	13.3	55
Yolo	HR	119.7	60.5	170	27	11.1	56
Anza	HR	113.1	60.7	171	27	11.7	52
Owens	SW	125.4	62.7	169	30	10.2	17
ID000392	SW	129.9	61.9	172	31	9.7	17
ID000420	HR	122.6	61.5	172	28	12.4	51
UC000785	HR	117.7	61.8	173	22	11.4	50
OR386306	HW	106.7	61.0	171	27	12.6	61
Alpowa	SW	123.0	62.4	171	30	10.1	8
McKay	HR	109.2	63.2	171	32	10.3	54
Federation	SW	101.1	58.6	175	39	10.4	7
Celia	TRIT	126.0	58.6	181	35	10.5	31
Juan	TRIT	125.2	59.1	169	36	9.4	40
Victoria	TRIT	156.8	56.7	168	34	9.3	32
Mean		114.1	60.5	171	29	10.9	33
$LSD_{(0.05)}$		23.6	2.3	2	2	1	14
CV (%)		13.0	2.0	1	5	5	26

[1] Calendar days from January 1 to 50% heading

[2] 1=very soft, 100=very hard

Bushel weights for the soft white wheats ranged from 62.4 pounds for Alpowa (WA 1993) to 58.6 pounds for Federation. Bushel weights for the hard red cultivars ranged from 63.2 pounds for McKay to 60.2 for Yecora Rojo. The bushel weight for the triticale Juan was significantly better than the bushel weight for Victoria.

Heading dates (50 percent headed) for the soft white wheats ranged from June 18 for Centennial and Owens to June 24 for Federation. Heading dates for the hard red types ranged from June 15 for WB 926 to June 22 for UC000785. The hard white Klasic headed on June 16, four days earlier than OR386306. The spring triticales

Victoria and Juan headed on June 17 and 18, respectively. Celia, which is considered a winter type, headed on June 30.

The OSU Advanced Line Spring Wheat Trial included five soft white cultivars, two hard white cultivars, and two hard red cultivars (Table 8). Yields for the soft white entries ranged from 103.8 bu/ac for OR880013 to 78.6 bu/ac for OR8427. Bushel weights for all entries, with the exception of Penawawa, were within the range of what is normally expected.

The average heading date (50 percent headed) for the nursery was June 21. Heading dates ranged from June 19 for the hard red cultivar OR4870456 to June 25 for the soft white cultivar OR880013.

At maturity, plant heights ranged from 33 inches for OR880013 to 25 inches for OR4870456.

Table 8. OSU Advanced Line Spring Wheat Trial conducted at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Type	Yield	Test weight	Moisture	Days to heading[1]	Plant height
		bu/ac	lbs/bu	%		inches
Owens	SW	89.6	60.20	11.3	171	27
Treasure	SW	98.0	58.60	11.5	171	30
Penawawa	SW	88.6	56.70	11.0	171	28
OR485010	HR	77.9	59.60	10.8	172	30
OR4870279	HW	88.5	60.30	10.4	171	29
OR4870456	HR	69.9	58.70	10.7	170	25
OR8427	SW	78.6	59.10	11.1	171	28
OR484013	HW	89.2	59.40	10.4	173	30
OR880013	SW	103.8	59.60	11.4	175	33
Mean		87.1	59.13	11.0	172	29
$LSD_{(0.05)}$		13.3	1.80	0.4	0.9	2.4
CV (%)		8.9	1.7	2.3	0.3	5.0

[1] Calendar days from January 1 to 50% heading

The relative poor performance of all entries and the severe symptoms of plant stress that were observed throughout the nursery area while the plants were actively growing suggests that growth and production were limited by some undetected factor. It is suspected that the poor performance was caused by an undetected nutrient deficiency or an injurious herbicide residue level from the preceding crop trial grown in that area of the field.

The OSU Statewide Spring Barley Trial included 12 six-row feed type cultivars, and one six-row and eight two-row malting type cultivars (Table 9). Yields for the six-row feed barleys ranged from 8,378 lbs/ac for UT150582 to 4,086 lbs/ac for ID85474. Yields for the two-row malting barleys ranged from 7,800 lbs/ac for Crystal to 5,149 lbs/ac for ID842974. Bushel weights for the six-row barleys ranged from 58.6 pounds for Russell, a malting type, to 53.2 pounds for UT150582. Bushel weights for the two-row malting barleys ranged from 58.9 pounds for ID842974 to 56.6 pounds for OR 1. Because the harvest samples from which the reported data were derived were thoroughly cleaned before the they were processed, the test weights reported here are unusually high.

Table 9. OSU Statewide Spring Barley Trial conducted at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

Variety	Type	Yield	Test weight	Days to heading[1]	Plant height
		lbs/ac	lbs/bu		inches
Baroness	2M	7190	58.6	175	26
Colter	6F	6781	55.8	171	27
Crest	2M	7131	57.6	175	27
Crystal	2M	7800	57.7	175	29
Marina	6F	6585	55.9	172	22
Russell	6F	4663	58.1	168	26
Steptoe	6F	7347	55.5	169	24
OR 1	2M	7090	56.6	176	25
OR 2	6F	7273	56.1	172	23
OR 3	6F	5949	56.4	171	19
Trebi	6F	6730	56.5	171	27
Gustoe	6F	8151	55.8	171	24
Columbia	6F	6836	56.1	174	26
UT11640	6F	7063	54.1	170	28
UT150582	6F	8378	53.2	171	28
UT502355	6F	5933	56.9	173	29
ID842974	2M	5149	58.9	175	25
BA2886-5113	2M	6911	58.3	175	27
ID85474	6F	4086	57.7	169	26
WA7190-86	2M	5547	57.4	175	24
MT140523	2M	6767	58.8	175	27
Mean		6636	56.8	173	26
$LSD_{(0.05)}$		1920	1	1	4
CV (%)		18	1	1	9

[1] Calendar days from January 1 to 50% heading

The average heading date (50 percent headed) for the nursery was June 22. Heading dates ranged from June 17 for Russell to June 25 for OR 1. The mean heading date for this trial occurred 60 days after planting. A review of data collected in previous spring barley trials at the Malheur Experiment Station suggests that for spring barley trials planted in mid to late March heading usually occurs 70 days after planting.

At maturity, plant heights within the six-row types ranged from 29 inches for UT502355 to 19 inches for OR 3. Heights for the two-row types ranged from 29 inches for Crystal to 24 inches for WA7190-86.

1993 WEATHER REPORT

J. Mike Barnum
Malheur Experiment Station
Oregon State University
Ontario, Oregon

Introduction

Daily observations of air temperature and precipitation have been recorded at the Malheur Experiment Station since July 20, 1942. Installation of additional equipment in 1948 allowed for evaporation and wind measurements. A recording soil thermometer was added in 1967. A biophenometer, to monitor growing degree days, and a pyranometer, to monitor solar radiation, were added in 1985.

Since 1962 daily readings from the station have been reported to the U.S. Department of Commerce, Environmental Science Service Administration, National Weather Service. Each day the 8:00 a.m. air temperature, preceding 24 hour air and soil temperature extremes, and 24 hour accumulated precipitation are recorded and transmitted to radio station KSRV in Ontario. KSRV then conveys this information, along with their daily readings, to the U.S. Weather Station in Boise, Idaho. During the irrigation season (April -October), evaporation, wind, and water temperature are also monitored and reported.

On June 1, 1992, in cooperation with the U.S. Bureau of Reclamation, a fully automated weather station, which is connected by satellite to the Northwest Cooperative Agricultural Weather Network (AgriMet) computer in Boise, Idaho, began transmitting data from the Malheur Experiment Station. The station monitors air temperature, relative humidity, dew point temperature, precipitation, wind run, wind speed, wind direction, solar radiation, soil temperature at 8 and 20 inch depths, and soil-water content at 8- and 20-inches. Data pertaining to the previously mentioned parameters are automatically transmitted to the computer at programmed 15- or 60-minute intervals. The database may be accessed via computer modem. During the irrigation season daily Malheur County crop water use estimates, which are based on data from this automated weather station, are also available by modem.

1993 Weather

Total precipitation for 1993 was well above the long-term station averages. Precipitation during the first half of 1993 (January through June) was 39 percent greater than the 51-year station average and 24 percent greater than the average of the last 10 years. Precipitation during the second half of the year (July through December) was below both the 10- and 51-year means (Table 1). Total precipitation for the year was 46 greater than the average for the last 10 years, and 24 percent greater than the 51-year station average (Table 2).

Precipitation accumulation for the fall-winter period October 1, 1992, through March 31, 1993, was 175 percent of the mean for the last 10 years and 146 percent of the 51-year mean for the same period (Table 3).

The mean air temperature (Table 4 and Figure 2) for 1993 was 1 percent above the mean of the last 10 years and 8 percent below the long-term 51-year average. The mean air temperature during the period March 1 to August 31 was 0.4 °F and 3.7 °F below the 10- and 51-year means, respectively (Table 4). With the exception of May, the mean air temperature for this period was consistently below average (Figure 2). The mean 4-inch soil temperature (Table 4 and Figure 3) for 1993 was 2.2 °F below both the 10- and 27-year means. During the period March 1 to August 31 the mean 4-inch soil temperature was 3.8 °F and 3.7 °F below the 10- and 27-year means, respectively (Table 4).

Mean evaporation during the 1993 irrigation season (April 1 through October 31) was 17.6 and 6.9 percent below the 10- and 46-year means, respectively (Table 5). Significantly lower than average evaporation amounts resulting from a combination of above average precipitation (Table 1) and lower than average temperatures (Table 3) during April and June, caused the seasonal evaporation to be well below normal. Near average wind-run conditions (Table 5) prevailed throughout the season. The combination of below average temperatures and average winds caused seasonal evaporation totals to be well below normal.

The last spring frost (≤32 °F) occurred 10 days ahead of the 20-year mean date of April 30; the first fall frost occurred on October 11, six days later than normal. Table 6 shows the dates of the last spring and first fall occurrences of minimum air temperatures equal to or below threshold levels of 24, 28, 32, and 36 degrees Fahrenheit for the past 20 years. Table 7 shows the number of days between the last spring occurrence and the first fall occurrence of those threshold temperatures.

Total cumulative growing degree days (≥50 °F and ≤86 °F) for the year were 17 percent below the seven-year mean (Table 8). Cumulative growing degree days at the end of May were nearly equal to the seven-year mean (Figure 4), however, below average accumulations of -30.7, -33, and -21 percent during June, July, and August, respectively, caused crops to grow and mature at a slower than normal rate.

Table 9 summarizes the weather conditions over the last five years and lists the historic record extremes for Malheur Experiment Station. Air temperature extremes for 1993 ranged from a high of 95 °F on August 3 and 7, to a low of -3 °F on November 23. In 1993 the maximum air temperature was ≥90 °F on 22 days compared to the average of 50 days for the previous four years.

Table 1. Daily and monthly precipitation totals for 1993 and monthly 10-year and 51 one-year precipitation means at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
	------------------------- inches											-------------------------
1	T			0.26		0.05						0.14
2	T		0.02	0.36		0.07						0.25
3			0.07	0.11	0.02	0.55						
4			0.02	0.41	0.17	0.06	T					0.08
5	T		0.08	0.28	0.08	0.25						
6		T				0.06				T		
7		T	0.01		0.20	0.31		0.02		0.05		
8	0.25				0.05			0.10		0.01		0.10
9	0.52	T		T								0.03
10			0.07	0.18								
11	0.03	T	0.12	0.04		0.10		0.03				
12		0.06		0.10		T				T		T
13	T							0.01		0.20		
14	0.40		0.03	0.25				T		0.04	T	
15	0.08	0.18	0.09				T	0.15		0.50		
16	0.06	T	0.15	0.17		0.02		0.17		T		
17	0.04	T	0.60	0.01		0.01	0.04	0.02				
18		0.25	0.32	0.17								
19		0.07		T								
20		T	0.06		0.13	0.01	0.01					
21		0.01										
22		0.07				0.06	0.04					
23		0.04					0.09				0.07	
24		0.34	0.11	T								
25			0.16	0.01								
26			0.21	0.04	0.05							
27			0.29									
28			T		T	T						
29				0.03							T	
30				0.13							0.57	
31												T
1993 total	1.38	1.02	2.41	2.55	0.70	1.55	0.18	0.50	0.00	0.80	0.64	0.60
10 yr mean	0.74	0.86	1.02	0.70	0.98	0.86	0.18	0.32	0.49	0.53	1.17	0.80
51 yr mean	1.29	0.96	0.98	0.79	0.97	0.82	0.20	0.45	0.52	0.70	1.18	1.29

Table 2. Annual precipitation 1984 through 1993 and 10-year and 51-year means at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	10 yr mean	51 yr mean
	------------------------- inches											-------------------------
Total	9.49	7.89	8.64	9.81	7.58	9.15	7.21	9.25	8.64	13.30	9.10	10.72

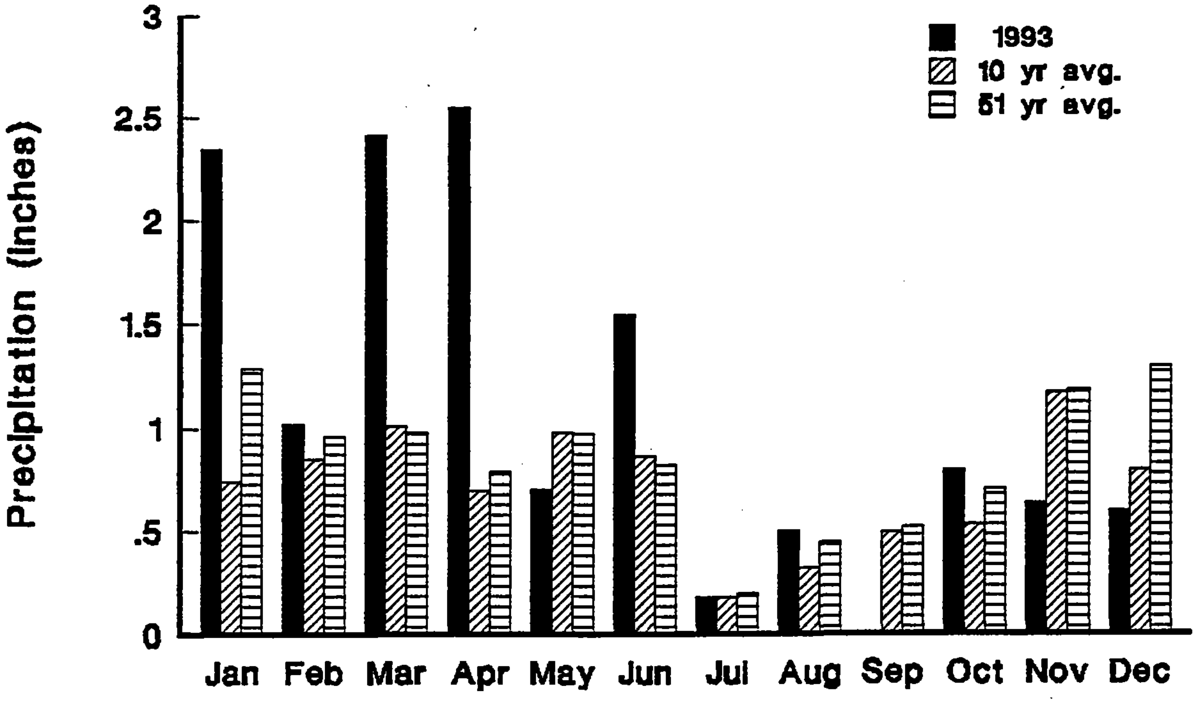


Figure 1. A comparison of the average monthly precipitation for 1993 to the 10- and 51-year averages at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

Table 3. Ten-year (October through March) monthly precipitation totals and 10- and 51-one year means at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

		1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	10 yr	51 yr
Oct		0.63	0.71	0.12	0.00	0.00	0.86	0.49	1.01	0.95	0.80	0.56	0.70
Nov		1.59	1.05	0.22	1.40	2.45	0.24	0.69	1.71	1.15	0.64	1.11	1.18
Dec		0.84	0.92	0.22	1.46	1.48	0.01	0.29	0.43	1.51	0.60	0.78	1.29
Jan	0.58	0.11	0.96	1.24	1.25	0.88	0.44	0.59	0.58	2.35		0.90	1.29
Feb	0.72	0.36	2.29	0.77	0.14	1.27	0.35	0.44	1.36	1.02		0.87	0.96
Mar	1.36	0.89	1.24	1.37	0.26	2.17	0.72	0.88	0.25	2.41		1.16	0.98
Fall[1]		3.06	2.68	0.56	2.86	3.93	1.11	1.47	3.15	3.61	2.04	2.45	3.18
Spr[2]	2.66	1.36	4.49	3.38	1.65	4.32	1.51	1.91	2.19	5.78		2.93	3.23
Total		4.42	7.17	3.94	4.51	8.25	2.62	3.38	5.34	9.39		5.37	6.41

[1] Fall = Total precipitation for October through December

[2] Spr = Total precipitation for January through March

Table 4. Monthly average high, low, and mean air temperature and monthly average high, low, and mean 4-inch soil temperature at Malheur Experiment Station, Oregon State University, Ontario, Oregon, 1993.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
							°F					
Air Temp.												
1993 high	30	33	46	61	78	76	80	84	81	67	44	42
1993 low	15	16	30	37	48	49	50	50	44	38	19	25
1993 mean	23	25	38	49	63	63	65	67	63	53	32	34
10 yr mean	22	29	41	49	56	64	69	68	58	48	34	24
51 yr mean	26	34	43	51	59	67	74	72	63	51	38	29
							°F					
Soil Temp.												
1993 high	31	32	43	59	75	77	83	84	77	64	42	36
1993 low	30	32	38	46	60	62	68	70	64	54	35	34
1993 mean	31	32	41	53	68	70	76	77	71	59	39	35
10 yr mean	31	35	46	57	66	74	82	81	71	58	42	32
27 yr mean	32	36	46	55	66	75	83	81	71	56	41	33

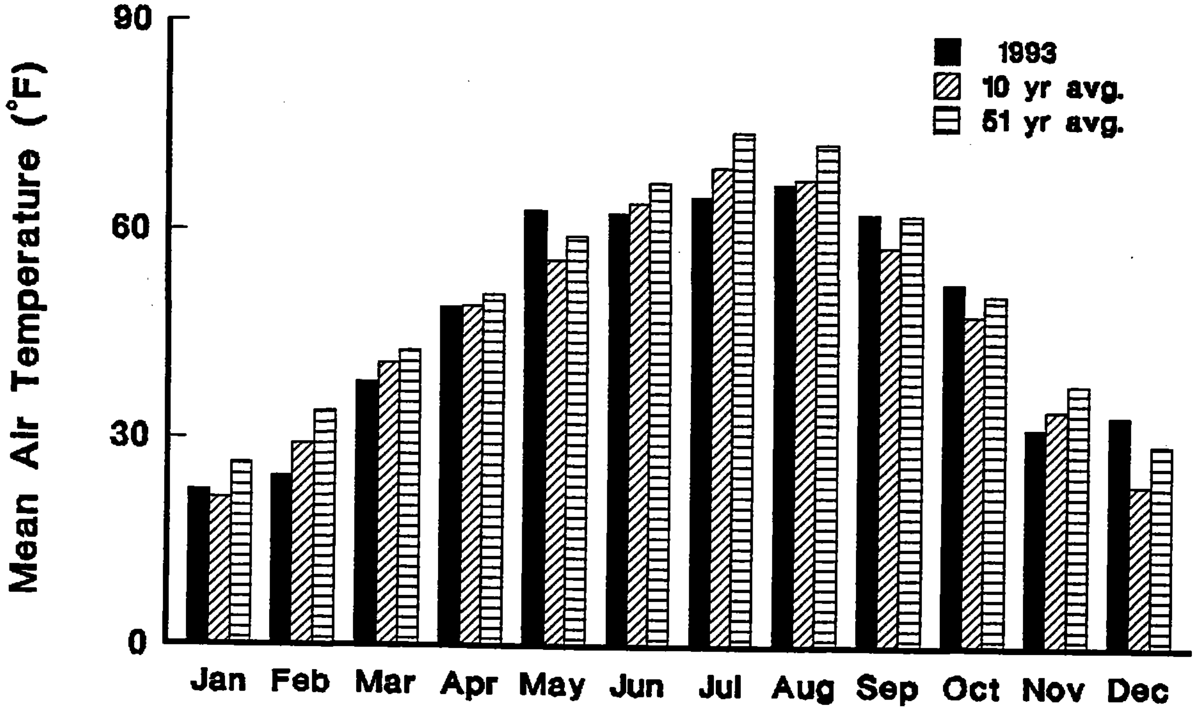


Figure 2. A comparison of the average monthly air temperature for 1993 to the 10- and the 51-year averages at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

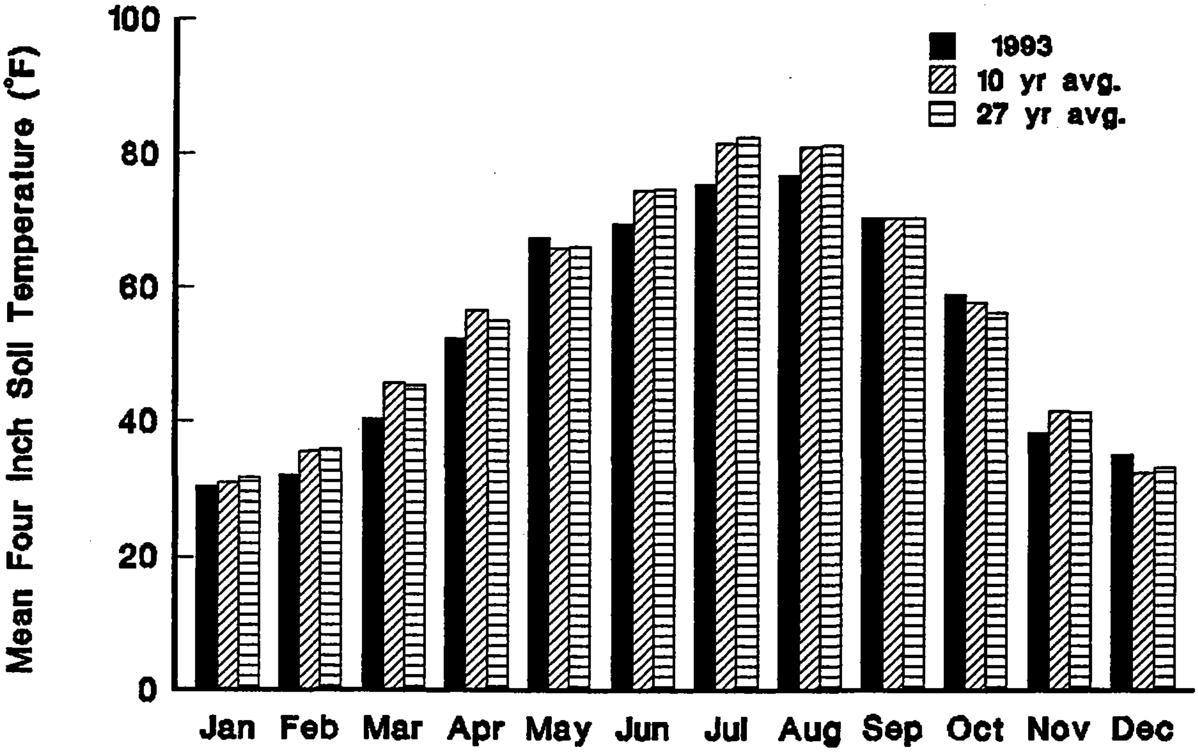


Figure 3. A comparison of the average monthly soil temperature for 1993 to the 10- and 27-year averages at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

Table 5. Ten-year monthly evaporation[1] and wind-run[2] totals and 10-year and 46-means for the seven month irrigation season (April 1 through October 31) at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

Year	Apr	May	Jun	Jul	Aug	Sep	Oct	Season total
	Evaporation							
1984	7.14	7.61	9.64	11.69	11.39	7.13	3.89	58.49
1985	7.22	8.93	10.86	12.68	10.58	5.73	3.47	59.47
1986	5.80	8.31	10.91	12.00	11.61	5.05	3.95	57.63
1987	8.13	9.55	9.51	11.46	11.08	8.30	4.92	62.95
1988	5.69	8.76	11.17	13.35	11.25	7.01	4.80	62.03
1989	5.79	8.74	10.78	12.84	9.73	6.65	3.76	58.29
1990	7.03	10.07	10.05	12.12	7.88[3]	8.54	2.99	58.68
1991	3.68	6.53	9.03	12.87	11.11	8.01	4.22	55.45
1992	5.70	11.23	8.37	10.13	9.86	6.70	4.15	56.14
1993	2.51	8.58	6.10	9.85	9.01	7.86	3.58	47.49
10 yr mean	5.87	8.83	9.64	11.90	10.35	7.10	3.97	57.66
46 yr mean	5.37	7.50	8.68	11.04	9.37	6.08	2.97	51.00
	Wind run							
1984	4405	3425	2985	2152	2139	2251	2290	19647
1985	2823	2787	2492	2111	2430	2268	2237	17148
1986	2308	2321	1792	2130	1740	1413	1544	13248
1987	2354	2432	1898	2161	1938	1620	1311	13714
1988	1889	2599	2357	2014	1879	1604	1294	13636
1989	1929	2620	1872	1707	1481	1465	1311	12385
1990	1832	2506	1824	1556	1276	1357	1427	11778
1991	2693	2677	2184	1680	1358	1316	1786	13694
1992	1797	2237	1711	1671	1580	1583	1158	11737
1993	1943	2060	2008	2138	1604	1505	1273	12531
10 yr mean	2397	2566	2112	1932	1743	1638	1563	13952
46 yr mean	2065	1860	1493	1423	1255	1187	1179	10463

[1] Inches of water evaporated from a standard 10 inches deep by 47½ inches diameter pan over 24 hours

[2] Total wind-run miles over 24 hours measured at 6 inches above the pan

[3] Due to an accidental draining of the evaporation pan at this station, the value reported is from the Parma Experiment Station, University of Idaho, Parma, Idaho.

Table 6. Dates of last occurrence in spring and first occurrence in fall of low temperatures for past 20 years (1974 - 1993) at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

Year	Last spring date and first fall date when minimum temperature was ≤ than threshold							
	Spring				Fall			
	≤24°F	≤28°F	≤32°F	≤36°F	≤24°F	≤28°F	≤32°F	≤36°F
1974	Mar 24	Apr 14	May 18	May 21	Nov 5	Oct 6	Oct 6	Sep 28
1975	Apr 2	May 25	May 25	May 26	Oct 24	Oct 24	Oct 8	Oct 8
1976	Apr 2	Apr 3	Apr 23	Jun 26	Oct 19	Oct 18	Oct 5	Sep 9
1977	Mar 31	Apr 15	Apr 20	May 5	Nov 3	Oct 11	Sep 22	Sep 22
1978	Mar 15	Mar 16	Apr 23	May 25	Oct 26	Oct 23	Oct 14	Sep 19
1979	Feb 7	Mar 19	Mar 20	Mar 26	Nov 10	Nov 2	Oct 27	Oct 10
1980	Mar 17	Mar 26	Apr 13	Apr 16	Oct 23	Oct 17	Oct 17	Sep 22
1981	Mar 18	Apr 14	Apr 14	May 7	Oct 22	Oct 22	Oct 1	Nov 23
1982	Apr 20	Apr 21	May 5	Jun 8	Oct 19	Oct 19	Oct 5	Oct 2
1983	Feb 6	Apr 11	Apr 27	May 14	Dec 2	Oct 16	Sep 20	Sep 10
1984	Mar 5	Apr 7	May 7	May 16	Oct 16	Sep 25	Sep 25	Sep 23
1985	Mar 26	Apr 20	May 13	May 13	Oct 9	Sep 30	Sep 30	Sep 18
1986	Feb 14	Feb 21	May 23	Jul 5	Nov 10	Oct 12	Oct 12	Sep 21
1987	Mar 30	Apr 20	Apr 21	May 2	Nov 18	Oct 11	Oct 11	Sep 27
1988	Mar 13	Apr 10	May 2	May 7	Nov 26	Oct 31	Oct 30	Sep 23
1989	Mar 5	Mar 30	May 19	May 25	Oct 29	Oct 16	Sep 13	Sep 13
1990	Mar 25	Mar 25	May 8	Jun 2	Oct 1	Oct 8	Oct 7	Oct 4
1991	Mar 16	Apr 8	Apr 30	May 9	Oct 30	Oct 30	Oct 4	Oct 4
1992	Feb 6	Apr 8	Apr 24	Apr 25	Nov 11	Oct 7	Sep 14	Sep 9
1993	Mar 12	Mar 12	Apr 20	Jun 12	Oct 30	Oct 27	Octo 11	Sep 17
Mean	Mar 15	Apr 6	Apr 30	May 19	Oct 30	Oct 15	Oct 5	Sep 26

Table 7. Number of days during the year that the minimum air temperature was greater than the threshold temperature during the past 20 years (1974 - 1993) at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

Year	Number of days minimum air temperature was greater than the threshold			
	>24°F	>28°F	>32°F	>36°F
1974	226	175	141	130
1975	205	152	136	135
1976	200	198	165	75
1977	217	179	155	140
1978	225	221	174	117
1979	276	228	221	198
1980	220	205	187	159
1981	218	191	170	200
1982	182	181	153	116
1983	299	188	146	119
1984	225	171	141	130
1985	197	163	140	128
1986	269	233	142	78
1987	233	174	173	148
1988	258	204	181	139
1989	238	200	117	111
1990	190	197	152	124
1991	228	205	157	148
1992	278	182	143	137
1993	232	229	174	97
Mean	231	194	158	131

Table 8. Monthly cumulative degree days (lower threshold = 50 °F, upper threshold = 86 °F) for past eight years (1986-1993) at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	0	16	101	220	558	1197	1847	2643	2939	3097	3111	3111
1987	0	0	43	318	741	1288	1929	2578	3064	3287	3316	3318
1988	0	5	56	236	554	1139	2050	2741	3117	3426	3446	3446
1989	0	0	13	197	469	1018	1751	2332	2721	2838	2852	2852
1990	2	9	88	327	588	1085	1819	2454	3039	3077	3077	3077
1991	0	13	29	153	365	754	1530	2248	2684	2878	2879	2879
1992	0	13	119	321	803	1377	2016	2720	3105	3279	3283	3283
1993	0	0	23	104	527	885	1349	1873	2281	2533	2539	2539
Mean	0	7	59	235	576	1093	1786	2449	2869	3052	3063	3063

Note: One day degree is accumulated for each one degree of average daily (24 hour) temperature that is above the lower threshold temperature and below the upper threshold temperature.

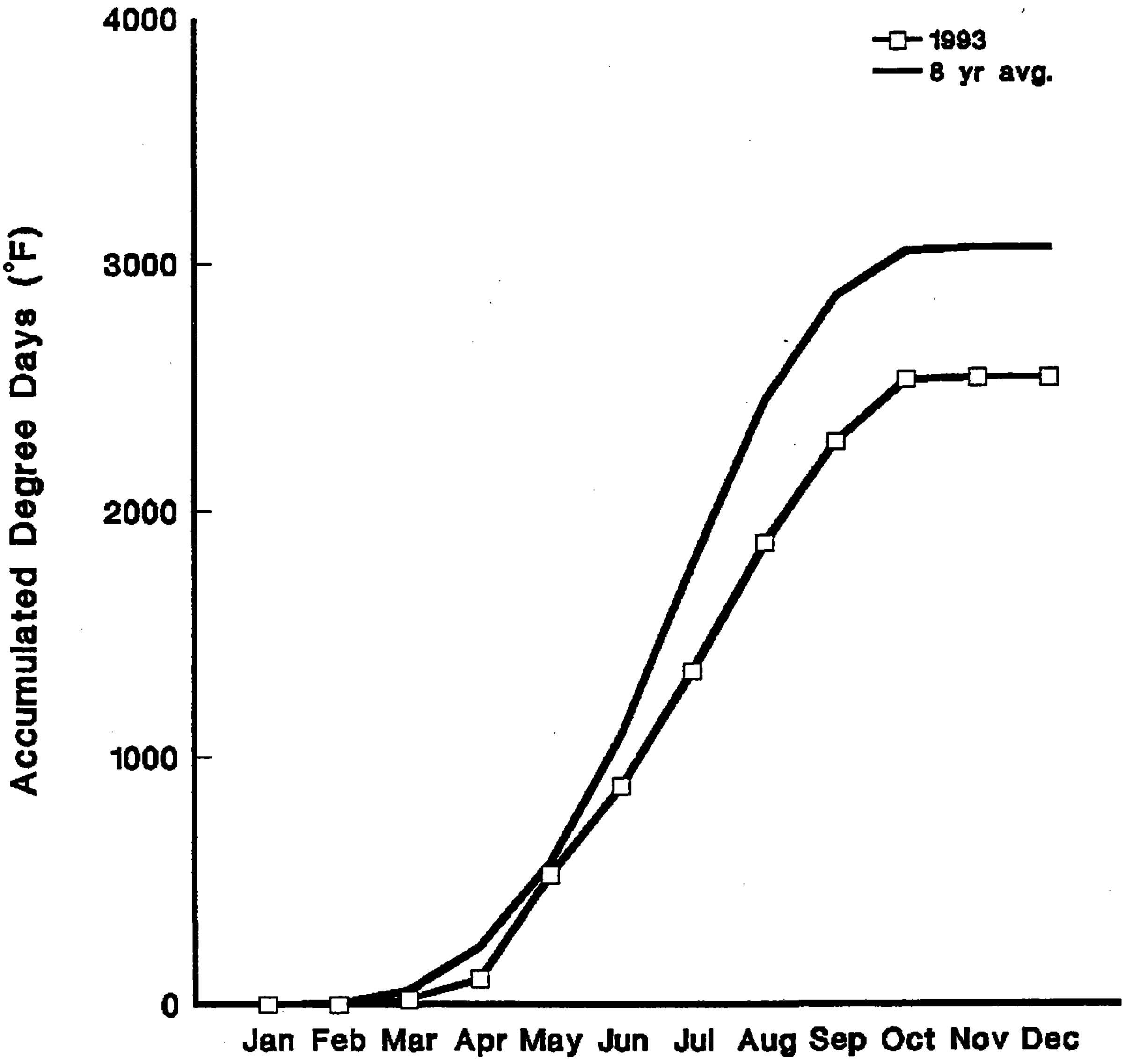


Figure 4. A comparison of the cumulative degree days for 1993 to the eight-year average at Malheur Experiment Station, Oregon State University, Ontario, Oregon.

Table 9. Five year, 1989-1993, weather summary and record extremes for Malheur Experiment Station, Oregon State University, Ontario, Oregon.

	1989	1990	1991	1992	1993
Total precipitation (inches)	9.18	7.26	9.25	8.64	13.30
Total snowfall (inches)	25.1	5.71	6.5	15.5	36.0
First fall snowfall:					
Date	Nov 23	Dec 25	Oct 29	Nov 12	Nov 23
Depth (inches)	0.1	1.0	0.5	0.5	1.0
Greatest amount of snow on ground:					
Date	Feb 18	Dec 28	Jan 10,11	Dec 9	Jan 19,20
Depth (inches)	17.0	2.0	4.0	8.0	15.0
Coldest day of year:					
Date	Feb 5-6	Dec 22	Jan 2	Dec 6	Nov 23
Air temperature (°F)	-24	-21	-3	-11	-3
Hottest day of year:					
Date	Jul 28	Aug 8	Jul 5, Aug 10,23	Aug 15	Jul 29, Aug 3,7
Air temperature (°F)	103	106	99	105	95
Number of days air temperature was:					
≤0°F	15	9	2	3	6
>0°F & ≤32°F	141	137	139	118	135
≥90°F & <100°F	34	50	52	39	22
≥100°F	7	10	0	11	0
Soil Temperature extremes @4":					
Date	Jul 28	Aug 9	Jul 29-31, Aug 8,20	Aug 15	Aug 6,7
Highest (°F)	95	96	93	96	90
Date	Dec 14,27, 31	Dec 24-26	Jan 3	Jan 22	Jan 7-8, Nov 26-28
Lowest (°F)	28	12	12	30	24
Wind run extremes:					
Total days run ≥125 miles	N/A*	25	31	13	16
Total days run ≥200 miles	N/A	4	3	0	5
Date of greatest wind run	N/A	Apr 24	Apr 11	Nov 22	Jan 1
Wind run in miles	N/A	301	278	197	291

Record extremes:

Maximum air temperature: 108°F, August 4, 1961
Minimum air temperature: -26°F, January 21 and 22, 1962
Minimum 4" soil temperature: 12°F, December 24 through 26, 1990
Greatest amount of precipitation in 24 hour period: 1.52 inches, September 14, 1959
Greatest amount of snowfall in 24 hour period: 10.0 inches, November 30, 1975

* Prior to 1990 no wind records were kept for the winter months (November - March) at this station