Special Report 1007
July 1999

Research in the Klamath Basin
1998 Annual Report
in cooperation with Klamath County

Agricultural Experiment Station
Oregon State University

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Introduction

Klamath Experiment Station (KES) staff are pleased to present this summary of our research activities conducted during 1998. While some of our findings are limited to one year, we caution our readers that multiple years and or locations provide much greater confidence that results are reproducible. Many of our activities are joint projects with other Oregon State University (OSU) units and neighboring states' institutions. Where possible, we have summarized over years and locations, sharing results observed at other institutions. We hope our report will provide our colleagues, clientele, and other interested parties with useful insights into some of the challenges and opportunities of agricultural production in an increasingly environmentally conscience society. Brief summaries of some of our current and past research projects can be accessed by our Internet home page at:

http://www.orst.edu/dept/kes.

We welcome your comments and suggestions that enhance our ability to serve our clientele and communicate our findings. Our e-mail address is:

kenneth.rykbost @ orst.edu.

Financial support of our staff, facilities, and projects is derived from a variety of sources. The Oregon Agricultural Experiment Station (AES), through legislative appropriation, provides the majority of support for full-time staff. Klamath County owns the land and buildings, has provided some of the equipment, and funds the majority of salaries and benefits for two full-time employees. We greatly appreciate the continuing support of the Klamath County Board of Commissioners and the Klamath County Budget Committee. Much of the operational support for the station and our programs is derived from gifts and grants. We identify these sources of funding in acknowledgements for individual projects.

Most of our research activities are conducted in collaboration with colleagues from the OSU campus, other OSU branch experiment stations, sister institutions in neighboring states, Cooperative Extension, and industry. Where appropriate, our colleagues are recognized by authorship on project reports. A partial list of cooperators follows. Special recognition of the University of California Intermountain Research and Extension Center staff is due for the very close cooperation enjoyed in many of our efforts in both research and extension programs over the past 12 years.

We also wish to acknowledge the guidance and counsel provided by the station's advisory board members, past and present, formally and informally. Agriculture in general and Klamath Basin agriculture in particular faces many new and difficult challenges. Fine tuning of management practices through varietal improvement, better pest control methods and tools, precision farming technologies, new crop alternatives, and most recently, use of genetic engineering breakthroughs, has been the focus of Land Grant institutions, the Oregon AES, and KES. This focus is no longer adequate to insure success in a climate where regulatory loss of crop protection tools occurs before replacements are available, untried management practices are proposed by regulatory agencies with little understanding of economic implications, and long-standing priorities for irrigation water supply are suddenly superceeded by Federal policy shifts.

Through consultation with our advisory board members and many other clientele in the agricultural community, and with colleagues from the University of California, KES programs are shifting emphasis somewhat. Input to the public policy process has increased through participation in opportunities for comment on Federal agency policy changes. Service to local committees planning strategy for agricultural responses to water quality concerns for Oregon Department of Agriculture and Department of Environmental Quality is an increasing focus. Additionally, KES staff have become involved in reviewing previous research reports on water quality issues affecting the watershed and are beginning a small scale monitoring program. A preliminary report on our efforts in this area is included.

The shifting emphasis is not without consequences for traditional programs. A significant reduction in potato and sugarbeet research occurred in 1998. While the very difficult field conditions in the wet spring were partially responsible, the need to address water availability for irrigation is an overriding concern for survival of a viable agricultural industry in the Klamath Basin. Our efforts in this area will continue and expand in the short term.

Kenneth A. Rykbost
Superintendent
Klamath Experiment Station

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We deeply appreciate their involvement and contributions to KES research efforts.

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Contents

Weather and Crop Summary, 1998

K.A. Rykbost and B.A. Charlton[1]

Weather records for the Klamath Falls area date back to U.S. Water Bureau observations from 1884. An official National Oceanic and Atmospheric Administration (NOAA) station was established at the Klamath Falls airport at Kingsley Field in 1949. Kingsley Field is located at 42°09'N latitude, 121°44'W longitude, and 4,092 ft elevation. This station was officially closed in 1996. A station established at the Klamath Experiment Station (KES) one-quarter mile west of Kingsley Field was designated as the official NOAA station for Klamath Falls in 1997. Long-term comparisons between Kingsley Field and KES data show generally good agreement, although daily minimum air temperatures at KES are frequently 2 to 3 °F lower. This is probably due to the proximity of the Kingsley Field station to large buildings and paved areas. Both stations experience warmer minimum air temperatures than several important agricultural production areas in the Klamath Basin. During summer frost events, areas South of Tulelake, CA, are often 5 to 7 °F cooler than temperatures recorded at Klamath Falls.

A recent change in air temperature observations at KES will result in minor effects on minimum air temperature data. Previously, the minimum temperature thermometer was reset at midday to avoid the situation where a low at time of observation would be lower than the minimum during the following night. Starting in November, this is no longer done. Maximum and minimum temperatures are based on the 24-hour period from time of observation which is 7:30 am. Particularly during winter months, minimum temperatures will occasionally be higher than temperatures at time of observation on the previous day. With major frontal events, the differences can be quite large.

In 1998, the pattern of high precipitation extended into the fourth consecutive year. Precipitation in January was about double normal. A new rainfall record was established in May. November was also exceptionally wet. Total precipitation for those three months was nearly equal to the long-term annual precipitation at Klamath Falls (Table 1). For the third year in four, total precipitation at KES exceeded 19 inches, which is about 140 percent of normal (Table 2). Including the 14.29 inches recorded in 1997, the four-year total is greater than any four-year period dating back to 1884 (Table 3).

While mean annual air temperatures were about the same as averages over the past 14 years at KES, seasonal differences were observed. The frost-free season extended from May 22 to September 19 or 119 days. A typical frost-free season at KES is about 90 to 100 days, and frosts are possible and have occurred in any month. July, August, and September were warmer than normal with maximum

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[1]/Superintendent/Professor and Faculty Research Assistant, respectively, Klamath Experiment Station, Klamath Falls, OR.

air temperatures of 90 °F or higher recorded on 29 days. The 100 °F mark was reached on September 4 at KES for the first time in over a decade.

Temperature and precipitation records at Klamath Falls from 1970 to 1998 are compared in Table 2. Data for 1970 to 1983 was obtained from the NOAA station at Kingsley Field. Data from 1984 through 1998 were observed at the KES station. While 1998 mean air temperatures were identical to the long-term average, precipitation for the year was 153 percent of average. Growing-season precipitation was 172 percent of average.

Growing-season weather is presented in greater detail in Tables 4 and 5. The 30-week period from April 1 through October 27 encompasses most local field activities from land preparation through harvest of crops. The last two weeks in April were warmer than normal, and soils were dry enough to allow some early planting; however, rain starting on May 5 stopped most field work for two weeks. Intermittent rainy periods continued through the first week of June. Many fields in the northern part of the Klamath Basin were planted after June 10, a delay of about four weeks from normal. Air temperatures were above normal from mid-July through mid-September. Nearly 2 inches of rain/snow during the first 11 days of November stopped further field work.

The weather patterns experienced in 1998 were sufficiently damaging to crop production that the area qualified for a Federal Disaster Declaration. The single most important factor was yield reductions caused by planting delays. Cereal and sugarbeet crops require early planting for maximum yield and quality. This has been demonstrated repeatedly in research projects. Effects of late planting were amplified by heat and disease stress later in the season. Soil compaction leading to cloddiness and poor water and root penetration on some of the mineral soils resulted from attempting field work while soils were still too wet.

The cool wet conditions of May and June favored several fungal diseases. Barley stripe rust appeared earlier than in previous years. Leaf rust was common in wheat and barley, and crown rust was a significant problem in oats. Net blotch and spot blotch were much more prevalent in cereals than normal for the region. Cereal yields were reduced by 30 to 50 percent by the combination of stresses imposed on crops.

Potato crops were being planted as late as the last week in June. In a few cases seed was disposed of and alternative crops such as oats for forage were substituted. Potato late blight was diagnosed on a sample collected on July 13 and occurred extensively by season's end. Verticillium wilt was a major problem in the Russet Norkotah variety. Early blight was more severe than has been previously observed, in spite of more rigorous fungicide programs to keep late blight in check. Pink rot and late blight tuber rot caused severe storage losses in a few cases and required early marketing of other storages to avoid greater losses. Potato yields were reduced from 1997 yields by 20 to 40 percent in worst cases and probably 10 to 15 percent in the best crops. A seed treatment experiment at KES with Russet Norkotah and nearly identical treatments in both years, produced 60 percent of 1997 yields in 1998. Soil clods were a serious problem for potato harvest and storage in some situations.

Sugarbeet acreage fell about 600 acres below contract expectations because of inability to plant early enough to achieve profitable crops. Yields were only slightly below 1997 yields, but average sugar content was about 0.5 percent lower. Sugarbeet diseases remained unimportant. Weed control was less effective than in recent years because timing of herbicide applications was affected by weather conditions.

Alfalfa first cuttings that weren't damaged by rain were generally overmature with some loss of quality. Second and third cuttings were reduced in yield in cases where rain-delayed baling also delayed return of irrigation. A significant portion of each cutting experienced rain damage. Forage production in pastures and rangelands was excellent. Stocking rates were too low to keep up with production in many cases. Grass hay production increased because of the under-utilization of pastures, creating an opportunity for hay production.

Table 1. Mean monthly temperatures for air and 4-inch soil and total monthly precipitation recorded at the Klamath Experiment Station, Klamath Falls, OR for 1998 and for 1984-97.

Month	Mean monthly temperature						Total precipitation
	Air			4-inch Soil			
	max	min	mean	max	min	mean	
	°F						inches
				1998			
January	43	29	36	34	33	34	3.18
February	43	28	35	35	35	35	1.21
March	51	29	40	40	38	39	1.58
April	56	30	43	43	41	42	0.35
May	57	36	47	48	47	47	4.28
June	73	42	58	58	56	57	1.25
July	86	51	68	68	66	67	0.08
August	87	47	67	68	66	67	0.00
September	81	42	62	63	61	62	0.37
October	62	28	45	50	48	49	0.62
November	44	27	35	40	40	40	4.86
December	36	13	25	34	33	34	1.73
Mean/Total	60	34	47	48	47	48	19.51
				1984-97			
January	39	19	29	33	33	33	1.68
February	45	23	34	35	33	34	1.11
March	52	27	39	40	37	39	1.33
April	59	31	45	48	44	46	0.92
May	66	37	51	55	50	52	1.10
June	74	43	59	63	56	59	0.87
July	82	48	65	69	62	65	0.44
August	83	46	65	69	62	66	0.41
September	76	40	58	63	57	60	0.77
October	65	31	48	54	49	51	0.76
November	48	24	36	43	41	42	1.54
December	38	19	29	36	35	36	1.68
Mean/Total	61	32	46	51	47	49	12.61

Table 2. Mean air temperatures for April through September, mean 4-inch soil temperatures for May through October, and total precipitation for April through September and annually from 1970-98 at Klamath Falls, OR.

Year	Air temperature Apr.-Sept. max	min	mean	4" Soil temperature May-Oct. max	min	mean	Total precipitation Apr.-Sept.	annual
	°F						inches	
1998	73	41	57	59	57	58	6.95	19.51
1997	73	41	57	60	57	58	4.52	14.29
1996	72	39	56	61	59	60	5.50	19.54
1995	72	40	56	61	57	59	7.10	19.06
1994	76	40	58	63	59	61	3.42	7.72
1993	70	38	54	60	55	58	5.82	14.96
1992	77	42	60	66	58	62	3.41	11.34
1991	73	40	57	61	55	59	3.41	9.29
1990	74	41	58	61	55	58	5.66	12.46
1989	72	40	56	62	55	59	5.16	12.08
1988	75	41	58	64	56	60	3.13	10.15
1987	76	41	59	65	56	61	3.24	10.13
1986	73	42	58	70	59	64	3.87	13.06
1985	74	40	57	64	53	59	5.50	10.13
1984	71	41	56	70	57	64	4.36	13.32
1983	69	40	55	73	59	66	3.88	18.56
1982	70	40	55	71	57	64	4.18	13.90
1981	74	42	58	73	58	66	2.43	15.57
1980	71	41	56	74	59	67	2.75	11.03
1979	74	42	58				3.77	14.10
1978	70	40	55	71	58	65	4.57	9.30
1977	73	43	58	71	58	65	4.97	12.37
1976	69	41	55	72	57	65	4.94	8.70
1975	71	41	56				4.10	13.21
1974	74	42	58	70	56	63	1.82	8.64
1973	75	42	59	69	55	62	1.29	11.03
1972	73	41	57				1.87	11.72
1971	70	40	55				4.68	12.68
1970	74	39	57	70	57	64	1.25	12.61
Mean	73	41	57	68	57	62	4.05	12.77

Table 3. Annual precipitation for Klamath Falls, OR, recorded by the U.S. Water Bureau (U.S.WB) (1884-1948), National Weather Service (NOAA) (1949-98), Klamath Experiment Station (KES) (1984-98).

Year	Precipitation inches	Year	Precipitation inches	Year	Precipitation inches	Year	Precipitation inches	
U.S. Water Bureau				NOAA				KES
1884	17.94	1921	11.94	1949	6.86	1979	14.10	
1885	18.71	1922	15.19	1950	13.56	1980	11.03	
1886	18.06	1923	9.85	1951	10.76	1981	15.57	
1887	10.71	1924	11.28	1952	10.97	1982	13.90	
1888	13.75	1925	14.26	1953	10.76	1983	18.56	
1889	10.40	1926	13.23	1954	8.57	1984	12.98	13.32
1890	IN †	1927	15.47	1955	11.31	1985	9.17	10.15
1891-99	NA ‡	1928	11.65	1956	12.52	1986	13.49	13.06
1900	NA	1929	8.56	1957	18.38	1987	10.11	10.13
		1930	9.44	1958	13.25	1988	10.32	10.15
				1959	6.72	1989	12.11	12.08
				1960	15.86	1990	13.33	12.46
1901	NA	1931	9.50	1961	13.21	1991	10.50	9.29
1902	11.26	1932	9.84	1962	16.92	1992	11.68	11.34
1903	IN	1933	11.01	1963	10.41	1993	16.78	14.96
1904	15.04	1934	10.47	1964	15.45	1994	9.84	7.72
1905	8.32	1935	11.25	1965	10.12	1995	22.66	19.06
1906	14.87	1936	13.44	1966	11.50	1996	23.91	19.54
1907	16.67	1937	19.41	1967	9.21	1997	14.29	14.29
1908	10.02	1938	13.05	1968	10.18	1998	19.51	19.51
1909	17.67	1939	11.99	1969	15.38			
1910	14.70	1940	17.12	1970	12.61			
1911	9.73	1941	19.71	1971	12.68			
1912	19.56	1942	14.09	1972	11.72			
1913	16.11	1943	13.82	1973	11.03			
1914	11.42	1944	12.42	1974	8.64			
1915	11.72	1945	16.52	1975	13.21			
1916	10.98	1946	11.46	1976	8.70			
1917	10.22	1947	11.32	1977	12.37			
1918	9.51	1948	20.91	1978	9.30			
1919	9.40							
1920	12.22							

Means	1884-1948	13.22
	1949-1983	12.51
NOAA	1984-1997	13.65
KES	1984-1998	13.14

† IN: datum incomplete

‡ NA: datum unavailable

Table 4. Weekly average maximum, minimum, and mean air temperatures for the 1998 growing season and 1979-97 at Klamath Falls, OR.

Weekly period		1998 Weekly average max	1998 Weekly average min	1998 Weekly average mean	1979-97 Weekly average max	1979-97 Weekly average min	1979-97 Weekly average mean
		°F					
April	1 - 7	48	32	40	55	28	42
	8 - 14	47	26	37	57	30	43
	15 - 21	59	27	43	60	33	46
	22 - 28	65	35	50	59	32	45
	29 - 5	69	40	55	62	34	48
May	6 - 12	57	41	49	64	35	49
	13 - 19	54	33	44	67	37	52
	20 - 26	56	34	45	69	40	54
	27 - 2	61	38	49	69	41	55
June	3 - 9	71	42	57	70	42	56
	10 - 16	74	44	59	73	43	58
	17 - 23	76	43	60	76	44	60
	24 - 30	72	43	58	78	46	62
July	1 - 7	81	49	65	79	46	62
	8 - 14	83	50	66	81	48	64
	15 - 21	91	52	71	83	50	66
	22 - 28	91	56	74	85	50	67
	29 - 4	88	48	68	85	49	67
August	5 - 11	90	49	70	86	49	67
	12 - 18	88	49	69	84	47	65
	19 - 25	81	45	63	81	46	63
	26 - 1	89	46	68	80	43	61
September	2 - 8	94	51	72	80	43	62
	9 - 15	81	44	62	76	40	58
	16 - 22	76	36	56	73	39	56
	23 - 29	73	37	55	73	38	56
	30 - 6	68	33	51	73	36	54
October	7 - 13	65	33	49	68	34	51
	14 - 20	60	26	43	63	30	46
	21 - 27	64	29	46	61	31	46
Mean		72	40	56	72	40	56

Table 5. Weekly minimum air temperatures, frost days, and precipitation for the 1998 growing season and 1979-97 at Klamath Falls, OR.

Weekly period		Weekly min.		Frost days/week		Weekly precip.		Accum. precip.	
		1998	1979-97	1998	1979-97	1998	1979-97	1998	1979-97
		°F		%		inches			
April	1 -7	31	11	57	76	0.21	0.15	0.21	0.15
	8 - 14	20	15	86	66	0.14	0.16	0.35	0.31
	15 - 21	18	17	71	52	0.00	0.23	0.35	0.54
	22 - 28	20	20	28	53	0.00	0.27	0.35	0.81
	29 - 5	34	19	0	37	0.78	0.26	1.13	1.07
May	6 - 12	32	23	14	43	1.14	0.17	2.27	1.24
	13 - 19	26	19	14	31	0.98	0.24	3.25	1.48
	20 - 26	28	24	28	18	0.73	0.22	3.98	1.70
	27 - 2	34	27	0	18	0.65	0.32	4.63	2.02
June	3 - 9	34	27	0	8	0.44	0.27	5.07	2.29
	10 - 16	36	27	0	7	0.47	0.16	5.54	2.45
	17 - 23	38	30	0	4	0.14	0.08	5.68	2.53
	24 - 30	35	31	0	0	0.20	0.14	5.88	2.67
July	1 - 7	40	33	0	0	0.03	0.06	5.91	2.73
	8 - 14	45	34	0	0	0.00	0.05	5.91	2.78
	15 - 21	49	32	0	1	0.00	0.14	5.91	2.92
	22 - 28	50	35	0	0	0.05	0.04	5.96	2.96
	29 - 4	42	36	0	0	0.00	0.09	5.96	3.05
August	5 - 11	45	34	0	0	0.00	0.03	5.96	3.08
	12 - 18	41	29	0	2	0.00	0.12	5.96	3.20
	19 - 25	43	30	0	3	0.00	0.16	5.96	3.36
	26 - 1	42	32	0	1	0.00	0.18	5.96	3.54
September	2 - 8	47	29	0	4	0.00	0.08	5.96	3.62
	9 - 15	39	24	0	10	0.11	0.15	6.07	3.77
	16 - 22	31	24	28	13	0.00	0.22	6.07	3.99
	23 - 29	32	24	14	19	0.26	0.14	6.33	4.13
	30 - 6	25	20	43	22	0.00	0.07	6.33	4.20
October	7 - 13	23	18	43	40	0.24	0.16	6.57	4.36
	14 - 20	19	18	71	68	0.00	0.13	6.57	4.49
	21 - 27	24	15	86	63	0.38	0.33	6.95	4.82

Nutrient Loading in Klamath/Agency Lakes and Background Sources

K.A. Rykbost, B.A. Charlton, and R.L. Dovel[1]

Abstract

The implementation of the Federal Clean Water Act and Oregon Senate Bill 1010 is requiring the establishment of Total Daily Maximum Load (TMDL) allocations and Agricultural Management Plans for private lands in watersheds where water bodies have been placed on the 303d list as water quality limited. Many of the Upper Klamath Basin bodies have been listed with temperature the most common problem identified, but several other quality parameters cause concern in some cases. Many studies of water quality have been conducted on Klamath Lake and its tributaries, but much of the data have not been published in readily available sources. The reports that are available are fragmented, and generally ignore important background sources of water quality problems. This study was initiated in 1998 to review available reports, compile available data on nutrient loading as one quality parameter of concern for agricultural contributions, and develop additional nutrient loading data related to background sources. The latter objective resulted in the identification of significant background sources of phosphorus and nitrogen that may diminish or negate the importance of agricultural activities in supporting blue-green algae blooms on Klamath Lake which are widely perceived to be the cause of serious water quality conditions responsible for fish mortality. Findings shed new light on the real contribution of agricultural drainage waters on lake nutrient loading.

Introduction

Numerous studies have monitored nutrient loads in Upper Klamath Lake and its tributaries. Reports of some of these studies and their findings are found in several publications. Bureau of Reclamation (BOR) Annual Reports for 1991 and 1992 include brief reports on several studies (Campbell and Ehinger, 1993; Campbell, Ehinger, and Kahn, 1993; Sartoris and Sisneros, 1993). An extensive study in the 1960's is reported in Water Pollution Control Research Series (Miller and Tash, 1967). A U.S. Geological Survey/Bureau of Reclamation study conducted from 1993 to 1995 examined the contribution of nutrients in drainage water from agricultural lands adjacent to the lake to nutrient loading (Snyder and Morace, 1997). No overview of the nutrient loading question brings into perspective the many studies and potential sources of lake nutrient problems.

Kaffka, Lu, and Carlson (1995) monitored water quality parameters, including phosphorus (P) and nitrogen (N), in the Tulelake Irrigation District, reviewed data from numerous sources and studies, and attempted to quantify effects of agricultural activities within the irrigation district on water quality. They

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concluded that "... farming currently does not result in significant loading of surface waters in the Tulelake Irrigation District with P. Processes affecting P movement in the system are complex, however, and a better determination of patterns and processes awaits a more comprehensive analysis." They also concluded that agricultural activities probably did not contribute significant N loading to surface waters and perhaps agriculture serves as a sink for both N and P. Studies are continuing in the Tulelake Irrigation District by Kaffka and Carlson.

The most recent publication (Snyder and Morace, 1997) examining the nutrient contributions from drainage of agricultural lands, fails to provide important information needed to interpret their findings. In this brief report we hope to put this and other sources of data in perspective, provide a broader view of the nutrient status of the lake and other bodies of water in the region, and indicate needs for future work.

Review of Report 97-4059 and earlier studies

The 1993-95 USGS study monitored drainage water from Wocus Marsh, East Caledonia Marsh, Williamson River Ranch, Agency Ranch, and the Wood River Ranch in Klamath County (Snyder and Morace, 1997). Flow volumes were estimated from pumping- plant power consumption. Three to nine water samples from discharge pipes were analyzed for each pumping station. Mean total unfiltered nitrogen (total Kjeldahl nitrogen) and unfiltered phosphorus (according to procedures outlined in Quality Assurance Plan - Soil and Water Quality Laboratory, BOR Pacific Northwest Region) concentrations for the six pumping stations were as follows:

Wocus Marsh
Total N = 4.2 ppm   Total P = 0.21 ppm

East Caledonia Marsh
Total N = 4.2 ppm   Total P = 0.24 ppm

Williamson River Ranch
Total N = 3.5 ppm   Total P = 1.09 ppm

Agency Ranch (NW)
Total N = 1.7 ppm   Total P = 0.25 ppm

Wood River Ranch (7 Mile)
Total N = 3.3 ppm   Total P = 0.93 ppm

Wood River Ranch (Corral)
Total N = 2.7 ppm   Total P = 0.98 ppm

The study also attempted to estimate loss of nutrients from drained wetlands by soil analysis techniques. This method resulted in estimates of 3,000 tons of N and 60 tons of P lost annually from the agricultural lands monitored in the drainage water study. Additional data provided included a range of nutrients for Upper Klamath Lake of 0 to 10.6 ppm total N and 0.03 to 2.0 ppm total P, but no specific sample data. The report also included five sets of data from three artesian wells located on the Wood River

Ranch property. Nutrient concentrations of these samples ranged from 5.6 to 8.7 ppm total N and 2.0 to 7.3 ppm total P.

The 1960's study (Miller and Tash, 1967) attempted to develop a water budget for major sources of inflow to Klamath Lake and a nutrient budget for major nutrients. The main inflow sources were attributed to the Williamson River (46.2%), springs in the lake (17.4%), Wood River (14.7%), agricultural drainage (5.1%), Seven Mile Canal (4.6%), and precipitation (4.4%). Nutrient contributions were estimated to be derived from the following sources:

Pristine Streams
Total N - 0.4% Total P - 0.4%

Agricultural drainage
Total N - 20.1% Total P - 26.5%

Canals
Total N - 9.8% Total P - 5.1%

Springs
Total N - 11.4% Total P - 24.9%

Major Rivers
Total N - 58.4% Total P - 43.0%

Miller and Tash (1967) did extensive sampling and analyses of sediments in the bottom of Klamath Lake. They estimated the content of the top inch of sediments at 5,349 tons ammonia N, 2,972 tons nitrate N, 67,364 tons organic N, and 31,701 tons total P. They stated: "The quantity of nitrogen and phosphorus in only the upper 1 inch of lake sediments is as great as that quantity which would flow into the lake in the next 60 years if the present rate of inflow continues." They pointed out the need to determine the extent to which nutrients in the sediment can interchange with the overlying water.

The 1990-92 study by Sartoris and Sisneros (1993) includes data on water quality in Agency Lake collected in 1990, 1991, and 1992. Total N and total P data are shown in Table 1. Sampling dates were predominantly in summer months. In each year, nutrient concentrations were highest in the summer during algal blooms and lowest in winter. In 1990 and 1991, total P levels were highest in July and August, but remained elevated into September. In 1992, total P levels peaked in June and declined to quite low levels through August and September at both sites. Total N concentrations were also lower in 1992 than in 1990 or 1991 during late summer. This suggests less algal activity during the 1992 season when lake elevations were lower than in 1990 and 1991.

The range of total N and total P levels recorded by Sartoris and Sisneros (1993) are within ranges cited in Miller and Tash (1976) and Snyder and Morace (1997). The data sets clearly show quite high N and P levels during June through September. Although the data are not included here, soluble phosphorus accounted for the majority of total P, but nitrate and ammonia generally accounted for a small to very small fraction of total N. Means were calculated for each year and site. With uneven sample numbers and different sample dates the means are of limited value, but do indicate a significant concentration of both P and N in the lake compared to inflow sources shown in Tables 2 and 3.

Studies by Campbell and Ehinger (1993), and Campbell, Ehinger, and Kahn (1993) monitored the Wood River, Seven Mile Canal, Four Mile Canal, and Crystal and Thomason Creeks in 1990, 1991, and 1992 (Tables 2 and 3). The Wood River was monitored at five sites. Data from only two sites are included here: the Dixon Road site near the headwater springs, and the Agency Dike site near the mouth. In each year, the total P level approximately doubled from Dixon Road to the Agency Dike. Total N concentration doubled in 1990, increased three-fold in 1991, and increased five-fold in 1992. Mean P concentrations at Agency Dike were similar to mean Agency Lake P levels from 1991 and 1992, but maximum levels observed in Agency Lake were much higher. Total N at Agency Dike was much lower than levels in the lake. Nutrient levels in Seven Mile and Four Mile canals were similar to the Wood River in total P and slightly higher in total N. Interestingly, Crystal and Thomason Creeks, which are not exposed to agricultural influences, were slightly lower in total P, but higher in total N than Wood River.

KES Water Quality Monitoring Methods

All water samples were collected as grab samples then delivered to the Oregon State University (OSU) Soils Laboratory for analysis. Samples collected in August, September, and November were refrigerated as collected and delivered to the laboratory within 24 hours. Samples obtained in December and January were frozen immediately and maintained frozen until they were analyzed. Duplicate samples were obtained in several cases for quality control purposes. Total nitrogen and total phosphorus were determined using Kjeldahl digestion procedures.

Results and Discussion

The extremely high nutrient contents reported for three artesian wells in the Wood River Ranch (Snyder and Morace, 1997) were the catalyst for checking several artesian wells. Fort Klamath natives have indicated that the area at one time had about 1,500 developed artesian wells, and about 800 remain uncapped. On August 18, four artesian wells were sampled and a sample was also obtained from Crystal Springs. The same four wells and six additional artesian wells were sampled on September 30 (Table 4). The Seven Mile and McAuliffe Ranch wells are reported to be from an aquifer about 460 feet deep. Nutrient contents were quite low in both wells. Six wells in the Fort Klamath area reported to be from a different, but common 230-foot deep aquifer were varied but had much higher total P and total N. Two wells on the Wood River Ranch were very similar in nutrient levels to data reported by Snyder and Morace (1997) for these same wells. Clearly, the acquifer or acquifers feeding the artesian wells in the Fort Klamath area and Wood River Ranch are a background source of N and P unrelated to agricultural activities.

Several major springs that feed tributaries to Klamath Lake were sampled. All were less than 0.12 ppm total P and less than 0.21 ppm total N (Table 4). However, phosphorus levels in six of the springs were 0.07 ppm total P or higher, levels that exceed standards that have been established in other regions. These included the major springs that are the source of Wood River, Spring Creek, Fort Creek, and Crystal Creek. These levels are also adequate to support algal blooms according to data reported by Miller and Tash (1967), and represent additional background nutrient loading to Klamath Lake.

Several streams in the Upper Klamath Basin were sampled. The only sites that produced relatively high nutrient levels were in the Lost River and Klamath River. A Klamath River sample at Miller Island was similar in nutrient content to samples from the ADY Canal and the North Canal at their point of diversion into agricultural areas in Lower Klamath Lake (Table 1), suggesting nutrient loading prior to diversion for agricultural use in the Lower Klamath Lake area.

Sites in Klamath Lake that are the source of water flooded onto agricultural lands in winter were sampled. Water from Klamath Lake at Hank's Marsh floods Lakeside Farms in late fall. The Running Y Ranch, including Wocus Marsh and Caledonia Marsh, are flooded with water from the Geary Canal and Howard Bay, respectively. Klamath Lake was also sampled at the Lakeshore Drive bridge, the point of discharge to Link River or the A Canal (Table 1). All samples from Klamath Lake exceeded 1.0 ppm total N and most were 1.5 to 2.1 ppm total N. Phosphorus levels were between .10 and .25 ppm total P.

The most recent sampling has focused on water diverted from Klamath Lake to flood Wocus and Caledonia Marshes and on drainage water from those marshes. Results of our observations are compared with those reported by Snyder and Morace (1997) in Table 5. Wocus Marsh includes 3,800 acres (Snyder and Morace, 1997). The intake for flooding the marsh is at the south end of the Geary Canal and within 600 feet below the drainage pumps that discharge into Geary Canal. Some of the drainage is derived from rainfall and snowmelt from wooded uplands that drain into the marsh. With inflow and drainage occurring at the same time, some recirculation occurs. Drainage nutrient concentrations observed in KES data were very similar to results reported by Snyder and Morace (1997) (Table 5). The KES data shows that the majority of this loading can be attributed to the inflow water. Nutrient concentrations in inflow were 83 and 78 percent of nutrient concentrations in drainage for P and N, respectively, for the Wocus Marsh.

The Caledonia Marsh East includes 2,500 acres (Snyder and Morace, 1997). Inflow comes directly out of Howard Bay on the north side of the Marsh. The drainage discharge point is located several miles southeast of the inflow and discharges directly back into Klamath Lake. Nutrient concentrations in inflow were about 50 percent of concentrations observed at the inflow to Wocus Marsh (Table 5). Loading in drainage water in the KES tests was less than results reported by Snyder and Morace, 1997. Nutrient concentrations in inflow to the marsh were 52 and 76 percent for total P and total N, respectively, of concentrations in drainage water. Limited samples of drainage water from the west side of the Caledonia Marsh indicates similar nutrient levels in this area. Inflow to the west Caledonia Marsh comes out of Howard Bay about one-half mile north of the Geary Canal bridge. The discharge occurs just north of the bridge.

No attempt has been made to estimate volumes of inflow versus drainage. One purpose of flooding these lands is to recharge the soil profile for the following cropping season. Thus a significant volume of flood water remains in the marsh. Soils undoubtedly retain some of the nutrients in the flood waters. However, the data obtained in this 1998-99 sampling clearly show that nutrient loading of Klamath Lake from drainage of agricultural lands reported by Snyder and Morace (1997) was biased by failure to recognize contributions from inflow to the agricultural lands from the lake.

The relationships between inflow and drainage for agricultural lands at the north end of Klamath Lake (Williamson River Ranch) and adjacent to Agency Lake (Wood River and Agency Ranches) is different than for Caledonia Marsh, Wocus Marsh, and Lakeside Farms. Flood waters for these sites are not diverted out of the lakes, but out of tributaries including the Williamson River, Wood River, and Seven Mile Canal. Further monitoring is needed to determine relationships on these parcels where various restoration projects are underway.

Future Monitoring Needs

Additional investigations are needed to identify nutrient relationships within the Klamath Irrigation Project. Water diverted from Klamath Lake to the A Canal contributes about 60 percent of total project supply. Diversions from Clear Lake and Gerber Reservoir via Lost River and from the Klamath River via North and ADY Canals accounts for the balance of irrigation diversions. Tailwater from the project, including from Tulelake and Lower Klamath Wildlife Refuges, is discharged to the Klamath River through the Straits Drain. The Straits Drain is being considered as a point source for pollution in the Klamath River. Efforts are underway to establish Total Maximum Daily Load (TMDL) limits for the Klamath River between Lake Ewauna and Keno, as required for Water Quality Limited streams under the Clean Water Act. The components of quality-limiting parameters must eventually be assigned to point and non-point sources above the Straits Drain, including agricultural activities. Nutrients may or may not be one of the parameters requiring load allocations. The contributions of N and P in diversions from Klamath Lake and Klamath River need to be quantified and accounted for in the process. The KES is currently developing plans to monitor nutrient loading from these sources during the 1999 irrigation season. Activities will be coordinated with other agencies monitoring water quality in other parts of the Lost River and the Klamath Project.

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Table 1. Nutrient concentrations in Agency Lake in 1990 - 92 (Sartoris and Sisneros) and in Klamath Lake, Link River, and Klamath River in 1998 (KES).

Date	Agency Lake South Tot P	Agency Lake South Tot N	Agency Lake North (WS) Tot P	Agency Lake North (WS) Tot N
	ppm		ppm	
1/18/90	---	0.34		
3/16/90	0.08	0.86		
5/16/90	0.09	0.38		
6/11/90	0.13	2.11		
6/22/90	0.18	3.39		
6/29/90	0.21	2.47	0.32	4.17
7/9/90	0.26	2.37	0.44	4.73
7/12/90	---	---	0.64	8.65
7/18/90	0.25	2.13	0.41	3.84
7/26/90	0.28	2.47	0.34	3.63
7/31/90	0.16	0.98	0.33	1.25
8/8/90	0.28	2.47	0.55	6.52
8/14/90	0.28	1.36	0.37	2.82
8/21/90	0.25	1.70	0.48	5.18
9/4/90	0.19	2.17	0.17	1.85
9/11/90	0.18	3.42	0.16	2.60
9/18/90	0.27	4.30	0.14	2.23
10/2/90	---	1.78	---	---
10/9/90	0.27	1.50	0.25	1.99
10/17/90	0.25	0.92	0.27	1.54
11/27/90	0.58	0.57	0.11	0.92
Mean	**0.23**	**1.88**	**0.33**	**3.46**
2/25/91	0.07	0.26	0.06	0.19
4/3/91	0.08	0.66	0.07	0.48
4/30/91	0.12	0.47	0.04	0.49
6/5/91	0.07	1.20	0.14	0.55
6/19/91	0.08	0.58	0.14	0.54
7/1/91	0.09	1.29	0.26	3.16
7/17/91	0.32	2.08	0.38	2.09
8/1/91	0.34	1.57	0.42	1.27
8/14/91	0.30	1.41	0.29	1.15
8/28/91	0.40	2.97	0.28	0.90
9/11/91	0.42	1.19	0.38	0.92
9/26/91	0.33	1.31	0.32	0.94
10/10/91	0.12	1.00	0.06	0.38
11/1/91	0.11	0.53	---	---
11/22/91	0.07	0.53	---	---
Mean	**0.19**	**1.14**	**0.22**	**1.00**

Table 1. (continued) Nutrient concentrations in Agency Lake in 1990 - 92 (Sartoris and Sisneros) and in Klamath Lake, Link River, and Klamath River in 1998 (KES).

Date	Agency Lake South Tot P	Agency Lake South Tot N		Agency Lake North (WS) Tot P	Agency Lake North (WS) Tot N
	ppm	ppm		ppm	ppm
2/28/92	0.06	0.23		0.07	0.27
3/18/92	0.04	0.29		0.06	0.40
4/8/92	0.09	0.44		---	---
4/23/92	0.08	0.51		0.08	0.34
5/6/92	0.07	0.41		0.09	0.41
5/20/92	0.10	0.57		0.16	1.01
6/3/92	0.11	1.71		0.13	1.75
6/17/92	0.65	6.98		0.30	2.45
7/2/92	0.40	2.51		0.30	1.24
7/14/92	0.13	0.98		0.15	0.65
8/12/92	0.04	0.80		0.09	0.63
8/26/92	0.08	0.64		0.10	0.30
9/18/92	0.10	0.63		0.06	0.21
10/15/92	0.12	0.61		0.08	0.23
Mean	**0.15**	**1.23**		**0.13**	**0.38**
Klamath Lake	(at bridge on Lakeshore Drive)				
9/30/98	0.17	2.1			
11/4/98	0.08	1.7			
1/6/99	0.06	1.3			
1/13/99	0.05	1.5			
1/22/99	0.15	1.1			
2/4/99	0.08	1.1			
Hanks Marsh					
9/30/98	0.19	1.9	(Inflow)		
11/4/98	0.22	1.9	(Drainage from Lakeside Farms)		
1/6/99	0.27	1.4	(Drainage from Lakeside Farms)		
Link River					
12/23/98	0.06	1.5			
12/30/98	0.04	1.2			
Klamath River					
9/30/98	0.14	1.6	(Inflow to North Canal)		
9/30/98	0.16	1.4	(Inflow to ADY Canal)		
11/4/98	0.09	1.4	(At Miller Island boat dock)		

Table 2. Nutrient concentrations in tributaries to Klamath/Agency Lakes in 1990 - 91 (Campbell and Ehinger).

Date	Tot P	TKN	Tot P	TKN
	— ppm —		——— ppm ———	
Wood River at Dixon Road			**Wood River at Agency Dike**	
6/7/90	0.128	0.246	---	---
7/12/90	0.085	<0.03	0.164	0.463
8/7/90	0.085	0.619	0.197	0.731
9/6/90	0.088	<0.03	0.134	0.197
9/27/90	0.079	<0.03	0.108	<0.03
10/31/90	0.082	<0.03	0.099	<0.03
12/6/90	0.088	<0.03	0.113	0.121
Mean	**0.091**	**0.13**	**0.140**	**0.253**
1/6/91	0.078	<0.03	0.110	<0.03
2/5/91	0.081	<0.03	0.203	<0.03
3/6/91	0.073	0.03	0.162	0.490
4/2/91	0.064	0.03	0.085	0.100
5/6/91	0.045	0.06	0.075	0.300
6/4/91	0.079	0.06	0.200	0.220
6/24/91	0.080	0.04	0.140	0.160
7/24/91	0.079	0.05	0.180	0.410
8/20/91	0.074	0.03	0.120	0.190
9/17/91	0.076	0.04	0.120	0.130
10/9/91	0.073	0.01	0.110	0.060
11/4/91	0.092	0.18	0.079	0.060
12/4/91	0.076	0.04	0.100	0.070
Mean	**0.074**	**0.05**	**0.130**	**0.169**
7 Mile Canal at Mouth (Campbell and Ehinger)				
10/9/91	0.130	0.77		
11/4/91	0.078	0.03		
Crystal Creek at Mouth (Campbell, Ehinger, and Kahn)				
5/20/91	0.12	0.85		
7/23/91	0.12	1.03		
9/17/91	0.12	0.40		
Thomason Creek at Mouth (Campbell, Ehinger, and Kahn)				
5/20/91	0.17	1.16		
7/23/91	0.08	0.84		
9/17/91	0.14	1.18		

Table 3. Nutrient concentrations in tributaries to Klamath/Agency Lakes in 1992 (Campbell, Ehinger, and Kahn).

Date	Tot P	TKN	Tot P	TKN
	ppm		ppm	
Wood River at Dixon Road			**Wood River at Agency Dike**	
1/28/92	0.076	0.03	0.140	0.13
2/25/92	0.071	0.02	0.110	0.11
3/24/92	0.071	0.02	0.088	0.06
4/21/92	0.077	0.02	0.011	0.12
5/12/92	0.072	0.02	0.250	0.12
6/9/92	0.090	0.02	0.160	0.26
7/8/92	0.100	0.04	0.150	0.39
8/4/92	0.077	0.05	0.160	0.27
8/25/92	0.073	0.12	0.140	0.74
9/29/92	0.093	0.03	0.110	0.11
10/20/92	0.074	0.03	0.095	0.06
11/17/92	0.074	0.03	0.120	0.14
Mean	**0.074**	**0.04**	**0.153**	**0.21**
7-Mile Canal at Mouth			**4-Mile Canal at Mouth**	
1/28/92	0.083	0.08	----	----
2/25/92	0.066	0.30	----	----
3/24/92	0.090	0.20	----	----
4/21/92	0.120	0.65	0.065	0.23
5/13/92	----	----	0.094	0.32
6/11/92	----	----	0.099	0.26
7/8//92	0.200	0.71	0.110	0.48
8/4/92	0.290	0.80	0.110	0.44
8/25/92	0.240	1.82	0.110	0.38
9/29/92	0.130	0.48	0.100	0.50
10/20/92	0.086	0.15	0.091	0.14
11/17/92	0.098	0.21	0.090	0.32
12/8/92	0.097	0.33	----	----
Mean	**0.136**	**0.52**	**0.097**	**0.34**
Crystal Creek at Mouth			**Thomason Creek at Mouth**	
3/25/92	0.064	0.29	0.056	0.55
4/22/92	0.096	0.63	0.064	0.46
5/13/92	0.160	0.91	0.110	0.73
6/10/92	0.120	1.12	0.140	1.14
7/9/92	0.093	0.55	0.120	1.08
8/5/92	0.110	0.34	0.150	0.79
8/26/92	0.096	0.29	0.150	1.08
9/30/92	0.093	0.24	0.082	0.55
10/21/92	0.090	0.20	0.070	0.29
11/18/92	0.082	0.10	0.083	0.46
Mean	**0.100**	**0.46**	**0.103**	**0.71**

Table 4. Nutrient concentrations in springs and artesian wells in the Upper Klamath Basin (KES and Snyder and Morace).

Site	Date	Tot P	Tot N	
		ppm		
Springs				
Crystal Springs	8/18/98	0.11	---	
Odessa Springs	9/30/98	0.04	0.19	
Harriman Springs	9/30/98	0.04	0.20	
Threemile Creek Springs	9/30/98	0.02	0.19	
Mares Egg Springs	9/30/98	0.07	0.18	
Blue Springs	9/30/98	0.06	0.10	
Kimball Park Springs	9/30/98	0.07	0.12	
Fort Creek Springs	9/30/98	0.09	0.11	
Spring Creek Springs	9/30/98	0.08	0.10	
Hagglestein Park Springs	11/4/98	0.08	<0.20	
Artesian Wells				
Seven Mile	8/18/98	0.09	---	
	9/30/98	0.10	0.15	
McAuliffe Ranch Corral	8/18/98	0.09	---	
	9/30/98	0.11	0.12	
Porter Residence	8/18/98	0.79	---	
	9/30/98	0.75	0.50	
W. McAuliffe Residence	8/18/98	1.20	---	
	9/30/98	1.13	1.27	
Horseshoe Resort	9/30/98	0.69	0.47	
Church House	9/30/98	0.75	0.53	
Ft. Klamath Telephone Co.	9/30/98	0.31	0.30	
McNeary Residence	9/30/98	1.56	1.58	
Wood River Wetland (NW)	5/24/95	2.00	8.7	(Snyder et al)
	11/4/98	2.58	9.1	(KES)
	12/30/98	1.86	8.7	(KES)
Wood River Wetland (Cor)	7/13/93	6.4	6.0	(Snyder et al)
	4/7/94	7.3	7.0	(Snyder et al)
	5/24/95	6.4	5.6	(Snyder et al)
	11/4/98	5.9	5.8	(KES)
	12/30/98	6.1	5.8	(KES)

Table 5. Nutient concentrations in inflow and drainage waters of Wocus and Caledonia Marshes (KES and Snyder and Morace).

Site	(No. of samples)	Date	Inflow Tot P	Inflow Tot N	Drainage Tot P	Drainage Tot N
			ppm		ppm	
Wocus Marsh						
Snyder & Morace (9)		1993 - 95	—	—	0.21	4.2
KES		12/23/98	0.12	3.0	0.18	4.3
		12/23/98	0.13	3.1	0.20	4.7
		12/30/98	0.08	2.1	—	—
		1/6/99	0.14	2.6	0.18	3.1
		1/6/99	—	—	0.17	2.9
		1/13/99	0.13	3.5	0.12	3.5
		1/13/99	—	—	0.12	3.2
		1/19/99	0.15	3.3	0.16	3.4
		1/22/99	0.13	3.4	0.13	3.3
		1/22/99	—	—	0.13	3.3
		2/4/99	—	—	0.21	4.1
		2/12/99			0.21	4.8
		2/19/99			0.18	4.0
		2/26/99			0.18	4.0
		3/5/99	0.16	4.2	0.17	2.5
	Mean		**0.13**	**3.2**	**0.17**	**3.7**
Caledonia Marsh - East						
Snyder & Morace (3)		1993 - 94	—	—	0.24	4.2
KES		12/23/98	0.05	1.6	—	—
		12/23/98	0.04	1.4	—	—
		12/30/98	0.04	1.4	—	—
		1/6/99	0.04	1.4	—	—
		1/13/99	0.05	1.5	0.20	2.7
		1/13/99	—	—	0.22	2.7
		1/19/99	0.06	1.4	0.18	2.3
		1/19/99	—	—	0.20	2.3
		2/4/99			0.20	2.9
		2/12/99			0.30	2.9
		2/19/99			0.39	3.3
		2/26/99			0.31	3.2
		3/5/99			0.11	1.7
	Mean		**0.05**	**1.5**	**0.23**	**2.7**
Caledonia Marsh - West						
KES		1/19/99	—	—	0.18	2.4
		1/22/99	—	—	0.16	2.3
		2/4/99			0.16	2.3
	Mean				**0.17**	**2.3**

Sugarbeet Variety Evaluation in the Klamath Basin, 1998

K.A. Rykbost[1], D. Kirby[2], H. Carlson[2], and B.A. Charlton[1]

Abstract

The California Beet Growers Association (CBGA) sanctions official sugarbeet variety trials at the Oregon State University (OSU) Klamath Experiment Station (KES) and the University of California, Davis (U.C. Davis) Intermountain Research and Extension Center (IREC). In 1998, trials included 32 entries supplied by five seed companies. A one month delay in planting date at KES due to wet soil conditions reduced yield, sugar content, sugar production, and gross crop value significantly compared to IREC crop performance. Average beet yields were 27.5 and 31.0 tons/acre at KES and IREC, respectively. Average sugar content was 17.7 and 19.3 percent, respectively. KES crops produced an average of 2,200 lb/acre less sugar and $330/acre less gross crop value than IREC crops.

A new entry, 7CG7499, achieved the highest sugar yield at KES and was third highest at IREC. Among entries only evaluated over two years, excellent performance has been achieved by 5KG6907 at KES and by Beta 4043 at IREC. Nineteen entries in the 1998 trials have been evaluated in each year since 1996. As in previous years, significant performance differences were observed between locations for several selections. Leading varieties at KES, based on gross crop value, include HH 111, Bighorn, Monohikari, HH 88, and Beta 4885. The highest gross crop values over three years at IREC were achieved by Beta 8256, ACH203, Tomcat, KW6000 and HM7006. Differences in gross value among these selections were not significant at either location. Several of the highest yielding varieties at one site were among the lowest yielding selections at the other site. This relationship has been observed in most years, suggesting varietal response to site-specific soil or microclimate conditions.

Introduction

A local seed committee of the CBGA controls the acceptability of varieties for commercial production. The performance of varieties in official trials conducted at KES and IREC over three years and susceptibility to curly top virus determined in trials conducted in Idaho are the basis for commercial acceptability. To become eligible, varieties must

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achieve 97 percent of the average sugar yield of commercially accepted varieties and a curly top virus rating of not more than 125 percent of the USH-11 standard resistant variety. The CBGA provides entries to KES and IREC in a coded format with variety identity revealed only after performance data are presented to CBGA. The 1998 trials evaluated 32 entries.

Procedures

KES

The KES site was a Poe fine sandy loam soil cropped with oats for hay in 1997. The soil has a pH of about 6.0, organic matter content of approximately 1.0 percent in the plow layer, and somewhat restricted drainage because of a compacted layer at about 18-inch depth. The field was plowed in late April. On April 30 a broadcast application of 700 lb/acre of 16-8-8 fertilizer was incorporated with secondary tillage. A flat seedbed was firmed with a Brillion ring-roller. Several rain events delayed planting until May 22.

Varieties were planted with a hand-operated, one-row, Planet-Junior type planter. Seed was planted approximately 0.5 inches deep in 22-inch rows. Individual plots were two rows, 22 feet long with four replications, arranged in a randomized complete block design. Seeding rate varied depending on seed size, but in most varieties it ranged from 6 to 10 seeds/foot of row. Two border rows were planted on the east side and one on the west side of the trial. End plots included 5-foot borders. Stands were hand-thinned to approximately 9-inch plant spacing on June 30.

Weeds were controlled with 0.25 lb active ingredient (a.i.)/acre Betamix Progress applied with a conventional ground sprayer on June 5 and June 15. A minor flea beetle infestation was managed with carbaryl applied at 1.0 lb a.i./acre on June 15. Irrigation was applied with a solid-set system.

Beet tops were removed with a rubber flail topper immediately before harvest. Beets were lifted with one-row, tool-bar mounted lifters and hand harvested on October 19. All beets from both rows of each plot were counted and weighed. Samples of 10 beets from one row of each plot were sent to the Spreckels Sugar Company factory at Woodland, California, and analyzed for tare loss and sugar content. Total beet yields were adjusted to account for tare loss determined in the sample analysis.

Gross crop values were calculated for each plot based on beet yield and price per ton for beets at the observed sugar content, as determined by terms of the Spreckels Sugar Company contract. The price/ton is determined by the equation:

$$Price/ton = (3.158 \times \%\ sugar) - 15.4$$

for a net selling price of $24.00/cwt. Although net selling price varies slightly from year to year, a consistent price is used in the analysis of variety trial results. Beet population, beet yield, sugar content, total sugar production, and gross crop value data were analyzed statistically using MSUSTAT software. The 1998 data over locations were analyzed as a split-plot design with location as the main plot and variety as the split-plot. Three-year summary data were analyzed as split-split-plots with year as the main plot, location as the split-plot, and variety as the split-split-plot. For individual locations, three-year analyses used a split-plot design with year as the main plot and variety as the split-plot. Least significant differences are based on Student's *t* test.

IREC

The trial was conducted on Tulebasin fine silty loam soil with approximately 12 percent organic matter content, a highly fertile soil with near neutral soil reaction. The previous crop was spring barley. An application of 250 lb/acre of 16-20-0 fertilizer was broadcast preplant. Beets were seeded into 24-inch raised beds at 3.5-inch spacing with a modified, three-row cone planter on April 21. Planting depth was approximately 0.25 inches. Individual plots were three rows, 50 feet long, arranged in a randomized complete block design with four replications.

Weed control practices included: Poast 1.5 EC applied at 0.37 lb ai/acre on May 12, May 22, and June 6; Betamix applied at 0.25 lb ai/acre on May 9; and Betamix at 0.25 lb ai/acre plus UpBeet applied at 0.25 oz ai/acre on May 14 and May 31. Further weed control included cultivation on June 9 and June 26. Beets were hand-thinned at the 6-leaf stage to about 7-inch plant spacing. Irrigation was applied with solid-set sprinklers arranged in a 30- by 50-foot spacing.

Beet tops were removed with a rubber flail chopper immediately before harvest. Beets were harvested on October 21 with a modified one-row harvester. All beets from 45 feet of the center row were weighed and counted. Samples of approximately 25 lb/plot were analyzed for tare loss, sugar content, and impurities by Spreckels Sugar Company laboratory personnel. Data were processed as described above.

Results and Discussion

Average plant stands were similar at both locations (Table 1). Harvested beet populations ranged from 23,300 to 33,200 beets/acre at KES and 24,700 to 33,900 at IREC. Most varieties had populations near trial averages of about 29,000 plants/acre. Previous research at KES and IREC has demonstrated these differences in population have little effect on yield.

Nineteen entries in the 1998 trials have been included in local trials for at least three years. The entries Oasis, Beta 4043, 5KG6907, and 4KG5983 were evaluated in 1997 and 1998. Nine entries were included in the trials for the first time in 1998. A new entry, 7CG7499, achieved significantly higher beet yield than all other entries at KES and was third highest in beet yield at IREC. Averaged over locations, it was significantly higher in gross value than all other entries except 5KG6907 which also achieved high yields at both sites. Other entries with high yields and gross value included HH 111, Chinook, Monohikari, and Bighorn at KES and H943222, Oasis, and Owyhee at IREC. As in previous years, variety performance was affected by location. The interaction between variety and location was statistically significant for beet yield, sugar production, and gross crop value in 1998.

Sugar content was significantly higher at IREC than at KES. This was also true in 1997. Differences among varieties were significant at both sites. The lowest sugar content at both locations occurred in 96HX405 and 96HX804. The lowest sugar content in the 1997 trial was also observed in 96HX405 at both locations. HH 88, 4KG5983, Beta 1996, Monohikari, Beta 8256, and SS-T1 were among the highest in sugar content at both locations. In contrast to yield, sugar production, and gross value, the interaction between variety and location was not significant sugar content.

A three-year summary of performance of 19 entries is presented in Table 2. Using gross crop value as the best measure of performance, HH 111, Bighorn, Monohikari, and HH 88 were among the top entries at KES. At IREC, top performance was observed in Beta 8256, ACH203, and Tomcat, with several other entries nearly as high in gross value. Averaged over both locations, HH 111, HH 88, Bighorn, Tomcat, and KW6000 were among the highest in gross value. Blazer, Ranger, and ACH318 were among the lowest in gross value.

A two-year summary for four new entries and Bighorn and Monohikari standards is shown in Table 3. At KES, 5KG6907 has produced high yields in both years while Oasis and 4KG5983 produced less than the standards. Three of the newer entries achieved higher yields than Bighorn and Monohikari. Good performance among new entries to these trials shows promise that replacements for current commercial varieties will continue to emerge.

An additional research effort is planned for 1999 to examine the reasons for variety by location interactions observed in these trials. While most of the fields used for beet production in the northern portion of the basin are sandy soils similar to the KES site, reclaimed lake bed soils high in organic matter are also used. Crops produced in the southern portion of the basin are predominantly on organic soils. However, some crops are also grown on sandy soils. Variety selection by growers has usually been based on performance in trials within the geographic area crops are grown. However, there are reasons to believe that the performance responses are more likely to be related to soil type. In 1999, trials will be established on organic and sandy soil types in northern and southern areas to compare performance of selections that show strong location responses and others that perform similarly at both KES and IREC.

Table 1. Beet yield, sugar content, total sugar production, gross crop value, and plant population for 32 sugarbeet varieties grown at Klamath Falls, OR, (KES) and Tulelake, CA, (IREC), 1998.

	Beet yield			Sugar content			Sugar production			Gross crop value			Population		
Variety	KES	IREC	Mean	KES	IREC	Mean	KES	IREC	Mean	KES	IREC	Mean	KES	IREC	Mean
	ton/A			%			lb/A			$/A			1000 beets/A		
ACH 203	26.3	30.7	28.5	17.3	19.6	18.5	9100	12060	10580	1200	1650	1430	29.6	31.0	30.3
ACH 318	26.9	31.0	29.0	17.1	19.5	18.3	9150	12050	10600	1200	1640	1420	30.1	30.2	30.2
ACH 9800	28.8	29.6	29.2	17.4	19.3	18.4	10030	11390	10710	1320	1550	1440	25.7	26.6	26.2
Tomcat	27.2	29.9	28.6	17.8	19.4	18.6	9650	11590	10620	1280	1580	1430	32.3	30.9	31.6
Beta 1996	24.8	29.1	27.0	18.3	19.8	19.0	9050	11480	10270	1210	1570	1390	27.0	31.3	29.2
Beta 4885	26.9	30.7	28.8	18.1	19.4	18.8	9730	11920	10830	1300	1620	1460	29.8	32.0	30.9
Beta 8256	28.2	29.8	29.0	18.1	19.9	19.0	10200	11900	11050	1360	1630	1500	29.3	27.4	28.4
Beta 8422	26.1	31.0	28.6	17.4	19.4	18.4	9100	12000	10550	1200	1630	1420	29.8	32.9	31.4
Beta 8778	27.6	30.2	28.9	18.2	19.5	18.9	10000	11750	10880	1330	1600	1470	30.9	32.1	31.0
KW 6000	29.3	31.4	30.4	17.3	19.5	18.4	10120	12240	11180	1330	1670	1500	29.4	31.9	30.7
4 KG 5983	25.9	30.2	28.1	18.5	19.7	19.1	9600	11850	10730	1290	1620	1460	27.1	29.7	28.8
5 KG 6907	31.1	34.7	32.9	18.1	19.3	18.7	11180	13350	12270	1490	1820	1660	31.2	25.8	28.5
Beta 4043	27.1	31.7	29.4	17.7	19.1	18.4	9610	12090	10850	1280	1640	1460	31.1	30.8	31.0
6 CG 7120	24.7	30.6	27.7	17.9	19.4	18.7	8870	11840	10360	1180	1610	1400	29.7	28.8	29.3
7 CG 7499	34.1	34.6	34.4	17.4	18.5	18.0	11880	12820	12350	1570	1720	1650	32.0	24.7	28.4
HM 7006	28.7	30.3	29.5	17.6	19.6	18.6	10090	11830	10960	1350	1620	1490	33.2	28.7	31.0
Bighorn	29.0	29.3	29.2	17.9	19.1	18.5	10370	11180	10780	1380	1510	1450	29.6	27.3	28.5
Oasis	26.7	32.3	29.5	17.3	19.6	18.5	9230	12760	11000	1220	1730	1480	32.3	26.4	29.4
Owyhee	27.4	32.7	30.1	17.4	19.1	18.3	9540	12470	11010	1260	1690	1480	33.1	28.9	31.0

Table 1. (continued) Beet yield, percent sugar, total sugar production, gross crop value, and plant population for 32 sugarbeet varieties grown at Klamath Falls, OR (KES) and Tulelake, CA (IREC), 1998.

	Beet yield			Sugar content			Sugar production			Gross crop value			Population		
Variety	KES	IREC	Mean	KES	IREC	Mean	KES	IREC	Mean	KES	IREC	Mean	KES	IREC	Mean
	ton/A			%			lb/A			$/A			1000 beets/A		
Blazer	26.7	30.3	28.5	17.9	19.6	18.8	9570	11860	10720	1270	1620	1450	29.4	28.7	29.1
Chinook	29.3	30.8	30.1	17.9	18.9	18.4	10440	11660	11050	1390	1580	1490	29.6	33.9	31.8
Monohikari	28.3	30.3	29.3	18.5	19.5	19.0	10380	11790	11090	1390	1610	1500	30.5	30.1	30.3
Ranger	26.2	29.3	27.8	18.0	19.0	18.5	9400	11100	10250	1250	1510	1380	29.3	28.4	28.9
HH 88	26.4	31.0	28.7	18.7	19.7	19.2	9840	12190	11020	1330	1670	1500	28.4	29.0	28.7
HH 111	28.4	30.8	29.6	18.4	19.1	18.8	10460	11780	11120	1400	1600	1500	30.3	28.3	29.3
SS-T1	26.8	29.4	28.1	18.4	19.5	19.0	9880	11470	10680	1320	1570	1450	28.8	30.1	29.5
H 94 3222	26.1	34.4	30.3	17.6	18.9	18.2	9150	13000	11070	1210	1760	1490	30.1	32.9	31.5
96 HX 405	29.4	33.8	31.6	16.0	18.0	17.0	9430	12140	10790	1210	1620	1420	23.3	28.2	25.8
97 HX 706	26.7	31.5	29.1	17.8	19.4	18.6	9480	12180	10830	1260	1660	1460	23.4	27.7	25.6
98 HX 804	28.9	32.1	30.5	16.3	18.4	17.4	9430	11820	10630	1220	1590	1410	28.0	29.7	28.9
98 HX 805	24.7	29.9	27.3	18.1	19.5	18.8	8930	11670	10300	1190	1590	1390	23.6	27.2	25.4
98 HX 816	25.7	28.8	27.3	16.8	19.2	18.0	8650	11060	9860	1130	1500	1320	30.0	27.4	28.7
Mean	27.5	31.0	29.3	17.7	19.3	18.5	9740	11940	10840	1290	1620	1460	29.3	29.3	29.3
CV (%)	7	6	7	5	3	4	8	7	7	8	7	7	9	13	11
LSD (p = 0.05)	2.8	2.6	1.9	1.2	0.7	0.7	1060	1040	740	160	150	110	3.6	5.4	3.2

Table 2. Summary of sugarbeet variety performance at Klamath Falls, OR, (KES) and Tulelake, CA, (IREC), 1996-98.

Variety	Beet yield			Sugar content			Sugar yield			Gross crop value		
	KES	IREC	Mean	KES	IREC	Mean	KES	IREC	Mean	KES	IREC	Mean
	ton/A			%			lb/A			$/A		
ACH203	29.4	29.9	29.7	17.8	19.3	18.6	10460	11530	11000	1390	1570	1480
ACH318	30.6	29.4	30.0	17.4	18.9	18.1	10580	11100	10840	1390	1500	1450
Tomcat	31.2	29.9	30.6	18.1	19.3	18.7	11240	11530	11390	1500	1570	1540
Beta 1996	29.7	27.8	28.7	18.6	19.4	19.0	10990	10820	10900	1480	1470	1480
Beta 4885	30.4	28.0	29.2	18.7	19.2	18.9	11330	10740	11040	1530	1460	1490
Beta 8256	29.5	29.2	29.4	18.3	19.7	19.0	10720	11530	11120	1430	1580	1510
Beta 8422	30.5	29.8	30.1	17.7	19.2	18.4	10610	11410	11010	1430	1550	1490
Beta 8778	30.5	29.4	30.0	18.5	19.4	19.0	11220	11370	11300	1500	1550	1530
KW 6000	31.9	29.4	30.7	17.9	19.5	18.7	11450	11470	11460	1520	1560	1540
HM 7006	30.5	29.8	30.1	18.1	19.3	18.7	10900	11460	11180	1450	1560	1510
Bighorn	32.8	28.5	30.7	18.2	19.3	18.7	11850	11010	11430	1580	1500	1540
HH 88	30.3	29.1	29.7	18.9	19.6	19.3	11450	11380	11420	1550	1560	1550
HH 111	31.6	29.7	30.7	18.9	19.2	19.1	11930	11430	11680	1610	1550	1580
SS-T1	30.3	28.4	29.3	18.4	19.4	18.9	11060	10970	11020	1480	1490	1490
96 HX 405	33.3	32.6	33.0	16.1	17.8	17.0	10680	11650	11160	1370	1550	1460
Chinook	31.6	28.7	30.2	17.8	18.9	18.3	11120	10830	10980	1470	1460	1470
Ranger	30.4	28.8	29.6	17.8	18.8	18.3	10720	10820	10770	1420	1460	1440
Blazer	27.3	29.3	28.3	18.0	19.2	18.6	9790	11220	10510	1300	1520	1410
Monohikari	31.5	28.9	30.2	18.5	19.2	18.8	11560	11050	11300	1550	1500	1520
Mean	30.7	29.3	30.0	18.1	19.2	18.6	11040	11230	11130	1470	1520	1500
CV (%)	8	8	8	5	3	4	8	8	8	9	8	9
LSD (p = 0.05)	2.3	1.8	1.4	0.8	0.2	0.4	550	650	510	70	90	70

Table 3. Two-year summary of performance of six sugarbeet varieties grown at Klamath Falls, OR, (KES) and Tulelake, CA, (IREC), 1997-98.

Variety	Beet yield	Sugar content	Sugar yield	Gross value
	ton/A	%	lb/A	$/A
		KES		
Bighorn	33.6	17.5	11710	1550
Monohikari	32.2	17.6	11220	1480
5 KG 6907	34.9	17.5	12130	1600
Beta 4043	31.1	17.9	11140	1480
4 KG 5983	30.0	18.0	10540	1400
Oasis	29.9	16.8	9970	1300
Trial mean [1]	31.0	17.4	10720	1410
		IREC		
Bighorn	28.2	19.0	10760	1460
Monohikari	30.0	18.8	11240	1520
5 KG 6907	28.9	18.8	10860	1470
Beta 4043	31.1	19.1	11860	1610
4 KG 5983	30.8	19.1	11730	1590
Oasis	31.5	18.7	11850	1590
Trial mean [1]	30.2	18.8	11340	1530

[1]/ Mean for all entries in the 1997-98 coded trials.

Potato Variety Screening Trials, 1998

K.A. Rykbost and B.A. Charlton[1]

Abstract

The Klamath Experiment Station (KES) participates in the Oregon and regional potato variety development effort by assisting with early-generation selection and conducting replicated yield trials at the preliminary, statewide, and western regional levels. Two Oregon selections were released in 1998. Umatilla Russet (AO82611-7) is a dual-purpose russet, which is primarily of interest to the processing industry. Over 1600 acres of Umatilla Russet seed were certified in the USA and Canada in 1998. Russet Legend (COO83008-1) is also a dual-purpose russet, which has performed well for processing. Areas of Eastern Idaho are interested in Legend for table use. Over 750 acres of Russet Legend seed were certified in 1998. The russet selection, AO85165-1 continues to look promising for fresh market uses, particularly in the Klamath Basin. The Klamath Experiment Station plans to cooperate with local commercial growers to further evaluate this selection in 1999.

Because of high rainfall in May, the 1998 KES trials were planted late. Heat stress in late summer contributed to internal and external defects and generally poor performance in many of the selections at all trial levels. With the exception of AO87277-6, most of the russetted entries produced lower yields and less attractive tubers than in previous years.

Introduction

Progress in potato variety development has accelerated in recent years. Recent releases by Oregon and Idaho have contributed significantly to Pacific Northwest potato markets. Russet Burbank, the long-time industry standard for fresh market and processing production, is slowly being replaced by several new varieties. Ranger Russet is gaining acceptance for processing and Russet Norkotah is dominating for fresh market production in the Klamath Basin and Washington. Gem Russet (A8495-1), a recent Idaho release is expected to increase in both fresh and processing usage. Umatilla Russet, Russet Legend and Bannock Russet (A81473-2) are also finding acceptance. Traditional breeding programs continue to produce selections with superior quality for specific markets. This report summarizes the performance of selections in the Oregon and regional programs at Klamath Falls.

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Procedures

All trials were conducted on a Poe fine sandy loam soil in a 4-year rotation following spring cereals, sugarbeets, and spring cereals. Nematodes and related diseases were controlled with 18 gallons per acre (gpa) of soil fumigant Telone II applied at about 16-inch depth on 18-inch centers with a ripper in early November, 1997. All seed lots were hand cut to approximately 1.5 to 2.5 ounces (oz) per seedpiece, treated with Tops 2.5 MZ, at 1.0 pound per hundred pounds (lb/cwt), and suberized at 55 °F and 95 percent relative humidity for 5 weeks before planting.

Potatoes were planted at 8.7-inch spacing in 32-inch rows with an assisted-feed, two-row planter in all trials. Insecticide Di-syston was applied in the seed furrow at 3.0 lb active ingredient (a.i.)/acre at planting and Monitor was applied aerially at 0.75 lb a.i./acre on July 25. Fertilizer was banded on both sides of rows at 1000 lb/acre 16-8-8-14 at planting. Weeds were controlled with Dual, Prowl, and Matrix applied with a conventional ground sprayer at recommended rates. Irrigation was applied as necessary with solid-set sprinklers arranged on 40-foot by 48-foot spacing. Total crop water, including irrigation and rainfall, was approximately 17 inches.

Potatoes were planted on June 8 (statewide and regional trials) and June 9 (preliminary trial). The preliminary yield trial included 5 standard varieties and 37 numbered selections in 20-hill plots with 2 replications. Five standard varieties and 25 numbered selections were included in the statewide trial. The regional trial included 3 standard varieties, 8 numbered selections, 5 line selections of Russet Norkotah, and 1 private variety. All trials were arranged in a randomized complete block design and, except in the preliminary trial, included 30-hills/plot with 4 replications.

Fungicides, applied aerially, included Bravo 720 at recommended rates on July 16 and August 24, and Dithane at recommended rates on July 26, August 8, and September 20. Vines were desiccated with Diquat applied with a ground sprayer at 1.0 pint/acre on September 19 and September 28. Nu-Cop 3L was applied with the Diquat at recommended rates on September 28. Vines were shredded with a rotobeater one day before harvest.

Potatoes were harvested with a one-row, digger-bagger on October 6 (preliminary trial) and October 7 (statewide and regional trials). All tubers from each plot were stored at about 55 °F and 95 percent relative humidity until tubers were graded in mid-to-late October.

External tuber characteristics were noted for each replication during grading. Ten large (mostly > 12-oz) tubers from each plot were cut lengthwise and inspected for internal defects. Air and water weights were used to determine specific gravity on samples of approximately 10 lb of U.S. No. 1s in the 8-12 oz size fraction. USDA grade standards were followed to separate B size (< 4 oz), U.S. No. 1s (4-12 oz and >12 oz), U.S. No. 2s, and culls. U.S. No. 1 yields were not adjusted for external blemishes such as rhizoctonia and scab, or internal defects such as hollow heart and brown center. Samples of 6-12 oz tubers were saved from one replication of each selection in all trials for processing quality evaluation.

Since the preliminary trial only included two replications, data were not subjected to statistical analysis. In other trials, yield, grade, and specific gravity data were statistically analyzed using MSUSTAT software. Only a portion of the data collected is presented in this report. Decisions on the disposition of selections at all levels of evaluation are based on data accumulated at all trial locations. Preliminary and statewide trial data from four Oregon locations (Hermiston, Ontario, Powell Butte, and Klamath Falls) are compiled and reviewed by members of the Oregon Potato Variety Development Committee. Cooperators in 7 western states and industry members review regional data and determine disposition of those selections.

Results and Discussion

The 1998 growing season was a season of extremes. The Klamath Basin experienced record precipitation in May. Over four inches of rain delayed planting by several weeks. Early planted commercial fields showed sporadic emergence and seedpiece decay. In spite of a delay of five weeks between seed cutting and planting, excellent stands were achieved in all trials at KES. Unusually high temperatures persisted from mid-July, through mid-September. Because of late planting, vines were difficult to desiccate for many of the late maturing selections. Yields were generally low and internal and external defects were common in many selections. Variability between plots was greater than commonly observed in trials conducted at KES, as evidenced by higher coefficients of variability in statistical analyses. The difficult growing season conditions provided a good opportunity to observe the ability of selections to maintain acceptable performance under stress.

Preliminary Yield Trial

Most entries in this trial were selections from crosses made at Aberdeen, Idaho in 1992 through 1994. Several entries had excessive vine growth and immature skins at harvest which resulted in serious skinning damage. Effects of adverse conditions on crop performance are readily apparent in a comparison of yields in this trial with yields observed in the same trial in 1997. Total yield of U.S. No. 1s averaged 391, 487, 438, 424, and 518 cwt/acre for Russet Burbank, Ranger Russet, Shepody, Russet Norkotah, and Atlantic, respectively, in the 1997 trial. Only Shepody and Russet Norkotah produced within 100 cwt/acre of these yields in 1998 (Table 1). Average total yields for standards and selections retained for further evaluation were 604 cwt/acre in 1997 and 436 cwt/acre in 1998.

In the 1998 KES trial, Russet Burbank ranked 17th in total yield and 22nd out of 42 entries in No. 1 yield. Averaged over all locations, rankings were 12th and 28th, respectively. All selections retained produced higher No. 1 yields than Russet Burbank at KES. However, several selections produced relatively high yields of No. 2s and culls. Russet Norkotah had a much higher percentage of No. 2s than normal.

Several clones had better fry color than Russet Burbank. AO94205-1 and AO94266-3 both had excellent fry color scores of 1.0, but lacked the appearance quality of Russet Norkotah. AO94169-8 produced the highest total yield and yield of No. 1s and relatively few No. 2s and culls. Others worthy of mention based on all locations are AO94218-1 and AO94205-1. Entries selected from this trial are advanced to the 1999 statewide trial.

Statewide Trial

Crop development in this trial was similar to conditions experienced in the preliminary trial. Excellent stands were achieved in all selections (Table 2). Several entries had excessive vine growth and immature skins at harvest which resulted in serious skinning damage. Yields were generally low and internal and external defects were common (Table 3). Russet Burbank ranked 20th out of 30 in total yield and last in yield of No. 1s over all locations. Russet Norkotah produced higher yields than Russet Burbank at all locations.

Four clones were retained for further evaluation in the statewide trial and two clones were moved to the Tri-state trial. COO93031-1 ranked 1st in yield of U.S. No. 1s and 5th in total yield at KES. AO93317-5 ranked 2nd in yield of No. 1s and 3rd in total yield at KES. Both of these clones showed acceptable internal quality and will be evaluated in statewide trials again next year. AO92007-2 and AO92017-6 will be advanced to the Tri-state trials in 1999. All entries retained were later in maturity than Russet Norkotah and less attractive for fresh market use.

Several of the selections in the statewide trial are also included in Tri-state and regional trials. An attractive chipping selection, AO91812-1, performed well in regional chip trials in 1998. Yields and specific gravities are much better than Chipeta and Atlantic and chip color is exceptional. This selection will be retained in regional trials in 1999. AO88103-3 completed one year in Tri-state trials and was dropped from further evaluation due to a high incidence of hollow heart. AO87277-6 completed a second year in regional trials and has shown considerable promise as a dual-purpose russet with good yields. Processing scores have consistently been better than standard varieties and selections in the trials.

Western Regional Trial

Three Texas and two Colorado line selections of Russet Norkotah were included in this trial. All had later vine maturity than standard Russet Norkotah (Table 4). This was the final year for these line selections in the regional trial. Colorado has obtained Plant Variety Protection (PVP) for CORN-3, and CORN-8. Ownership of these selections has been transferred to the Colorado Certified Seed

Potato Growers Association. Texas is currently seeking PVP for TXNS112, TXNS223, and TXNS278, and the process should be finalized in 1999. In years past, most of the Russet Norkotah line selections have outperformed the standard Russet Norkotah in total yield and yield of US No. 1s. However, this year the standard Russet Norkotah outperformed all line selections (Table 5). The late planting and later maturity of the line selections probably accounts for the different yield response observed in the 1998 trial.

The relative yields of Russet Burbank and Russet Norkotah were the same as observed in preliminary and statewide trials. Russet Burbank yield was approximately 80 cwt/acre higher in the regional trial than in the preliminary and statewide trials. As usual, Russet Burbank had a lower percentage of No. 1s than most entries. Avalanche, a private variety, achieved the highest total yield while TX1385-12Ru achieved the highest yield of U.S. No. 1s. Hollow heart was a problem for many entries in this trial. Russet Norkotah and all the line selections had poor internal quality. Yields of No. 2s and culls were much higher than commonly observed in KES trials. AO87277-6, a dual-purpose russet has again shown considerable promise for processing. This selection has consistently outperformed standard varieties and most other selections in fry color. The OSU Foundation Potato Seed Program is planning on increasing AO87277-6 in greenhouse culture for 1999. Certified prenuclear seed stocks will be available to seed growers for rapid increase and commercial evaluation in 2000.

After reviewing data from all locations, three entries were dropped from further evaluation, six entries graduated from the regional trial, and five entries will be evaluated again next year.

Summary

The quality of advanced selections in the Oregon, Tri-state, and western regional potato variety development programs is excellent. Oregon has formalized the release of Umatilla Russet and Russet Legend. Likewise, Idaho has released Gem Russet (A8495-1), and Bannock Russet (A81473-2). Colorado finalized PVP on Russet Norkotah strains CORN-3 and CORN-8, and released Keystone Russet (AC83064-1) and Silverton Russet (AC83064-6). Texas is seeking PVP on Russet Norkotah strains TXNS112, TXNS223, and TXNS278 and plans on releasing TXAV657-27Ru as Stampede Russet. Traditional breeding lines have continually improved with regard to tuber type, appearance, processing quality, yield, and disease resistance.

Table 1. Tuber yield and specific gravity of entries selected from the Preliminary Yield Trial for further evaluation, Klamath Falls, OR, 1998.

Variety/	Yield U.S. No. 1s			Yield				Specific
selection	4-12 oz	> 12 oz	total	Bs	No. 2s	culls	total	gravity
Russet Burbank	223	46	269	67	38	26	400	1.083
Ranger Russet	198	53	251	33	36	21	341	1.089
Shepody	288	118	406	37	50	19	512	1.080
Russet Norkotah	246	109	355	41	68	1	466	1.070
Atlantic	141	153	294	25	0	63	382	1.088
AO94169-8	329	115	444	52	14	7	516	1.069
AO94203-3	274	39	314	34	11	6	365	1.082
AO94204-2	225	132	357	24	12	10	403	1.079
AO94204-7	223	90	313	41	20	41	415	1.074
AO94205-1	225	136	361	34	66	24	485	1.076
AO94218-1	208	209	417	27	47	49	539	1.070
AO94224-1	261	113	374	33	55	20	482	1.082
AO94266-3	179	126	305	18	37	1	360	1.097
Mean[1]	232	111	343	36	35	22	436	1.080

[1]/ Mean for standard varieties and clones selected only.

Table 2. Characteristics of entries in the Oregon Statewide Trial, Klamath Falls, OR, 1998.

Variety/ selection	Percent stand	Vigor rating[1]	Vine maturity[2]	Specific gravity	Percent H.H. & B.C.[3]
Russet Burbank	96	4.8	3.0	1.084	15
Ranger Russet	97	3.5	4.0	1.089	0
Shepody	97	3.8	3.3	1.074	0
Russet Norkotah	95	3.8	2.8	1.073	23
Atlantic	96	3.5	3.0	1.090	53
AO85165-1	97	2.0	4.0	1.079	30
AO87277-6	95	4.0	3.8	1.090	5
AO89128-4	98	4.3	3.8	1.093	8
AO90014-1	98	3.8	2.8	1.089	0
AO90319-1	95	3.5	3.5	1.083	0
AO88103-3	95	3.8	3.3	1.089	23
AO91812-1	88	4.0	4.0	1.090	0
AO91812-2	97	4.3	4.0	1.090	3
AO92007-2	94	4.8	3.3	1.083	5
AO92016-3	98	3.8	3.0	1.081	0
AO92017-6	96	3.5	3.8	1.087	3
AO92019-13	97	2.3	4.3	1.089	5
AO92023-3	98	3.8	4.0	1.076	0
AO92173-2	96	5.0	4.0	1.084	23
COO93031-1	95	4.8	3.5	1.075	0
AO92130-2	96	5.0	3.8	1.089	10
AO92246-3	96	2.3	4.3	1.080	5
AO92252-1	97	4.3	3.5	1.092	3
AO92260-8	98	2.8	4.8	1.084	0
AO92270-4	98	4.0	3.5	1.087	5
AO92281-3	99	3.5	4.5	1.090	3
A092303-3	97	4.5	3.3	1.096	53
AO92304-1	94	4.8	3.5	1.088	0
AO92378-1	98	3.8	3.8	1.083	0
AO93317-5	99	4.5	3.5	1.085	0
Mean	96	3.9	3.7	1.085	9
LSD (p = 0.05)				0.004	

[1]/ Vigor rating: 1 a small, weak plant to 5, a large, robust plant.

[2]/ Vine maturity: 1 for early to 5 for late.

[3]/ H.H. & B.C.: hollow heart plus brown center in 10 large tubers/sample.

Table 3. Tuber yield by grade for entries in the Oregon Statewide Trial, Klamath Falls, OR, 1998.

Variety/ Selection	Yield U.S. No. 1s			Yield			
	4-12 oz	> 12 oz	total	Bs	No. 2s	culls	total
	cwt/A						
Russet Burbank	216	56	272	45	45	43	406
Ranger Russet	182	81	263	21	52	52	389
Shepody	180	124	304	29	40	15	387
Russet Norkotah	255	105	360	34	26	8	428
Atlantic	182	93	275	48	0	45	368
AO85165-1*	178	57	235	40	22	37	334
AO87277-6*	235	74	309	32	23	10	374
AO89128-4*	262	46	308	46	26	32	412
AO90014-1*	200	28	228	57	17	4	306
AO90319-1*	166	0	166	59	11	8	244
AO88103-3*	265	61	326	62	30	11	429
AO91812-1*	270	84	354	38	0	3	395
AO91812-2	265	46	311	58	0	16	385
AO92007-2*	212	57	269	44	20	14	346
AO92016-3	200	20	220	39	26	84	369
AO92017-6*	231	90	320	37	42	28	428
AO92019-13	174	11	185	53	18	40	296
AO92023-3	186	154	340	25	37	22	423
AO92173-2	261	102	363	55	27	8	454
COO93031-1*	209	182	391	19	29	11	451
AO92130-2	308	66	373	76	22	3	474
AO92246-3	205	13	218	68	10	6	302
AO92252-1*	206	143	349	35	26	1	411
A092260-8	199	27	225	36	32	36	330
AO92270-4	202	34	236	50	11	6	303
A092281-3	216	63	278	26	31	9	345
AO92303-3	246	53	299	38	13	62	411
AO92304-1	298	79	377	51	26	28	482
AO92378-1*	242	101	343	30	11	0	383
AO93317-5*	306	78	384	43	17	20	464
Mean	225	71	296	43	23	22	384
CV (%)	19	42	27	19	61	68	14
LSD (p = 0.05)	59	42	17	78	20	21	73

* Retained for further evaluation

Table 4. Characteristics of entries in the Western Regional Trial, Klamath Falls, OR, 1998.

Variety/ selection	Percent stand	Vigor rating[1]	Vine maturity[2]	Specific gravity	Percent H.H. & B.C.[3]
Russet Burbank	98	5.0	3.3	1.086	5
Ranger Russet	97	4.0	4.3	1.088	5
Russet Norkotah	98	4.0	2.5	1.069	28
Shepody	98	3.8	3.0	1.073	3
AC87084-3	96	4.5	4.0	1.092	28
AO87277-6	98	4.8	3.5	1.091	10
CORN-3	96	3.5	4.3	1.076	28
CORN-8	99	2.8	3.8	1.072	18
NDD840-1	97	2.5	4.3	1.076	10
TX1385-12RU	98	4.3	3.3	1.079	28
TXNS 112	100	3.3	3.8	1.070	15
TXNS 223	98	3.8	3.5	1.072	35
TXNS 278	98	3.8	3.5	1.073	15
AC88042-1	99	4.3	3.3	1.080	0
AC88165-3	99	3.5	3.5	1.081	3
Avalanche	93	4.3	4.0	1.076	0
A88338-1	100	2.8	4.8	1.082	3
AO89128-4	99	4.5	4.3	1.091	5
Mean	98	3.9	3.7	1.079	13
LSD (p = 0.05)				0.004	17

[1]/ Vigor rating: 1 is a small, weak plant to 5, a large, robust plant.

[2]/ Vine maturity: 1 for early to 5 for late.

[3]/ H.H. & B.C.: hollow heart plus brown center in 10 large tubers/sample.

Table 5. Tuber yield by grade for entries in the Western Regional Trial, Klamath Falls, OR, 1998.

Variety/ selection	Yield U.S. No. 1s 4-12 oz	Yield U.S. No. 1s > 12 oz	Yield U.S. No. 1s total	Yield Bs	Yield No. 2s	Yield culls	Yield total
	cwt/A						
Russet Burbank	273	55	328	56	47	56	487
Ranger Russet	170	109	279	28	42	51	401
Russet Norkotah	236	129	365	35	26	8	434
Shepody	175	74	249	28	22	16	315
AC87084-3	184	71	255	46	50	24	375
AO87277-6	257	113	371	27	19	18	435
CORN-3	213	74	286	29	30	39	384
CORN-8	196	80	276	40	36	40	392
NDD840-1	207	80	287	40	25	17	369
TX1385-12RU	172	224	396	23	30	38	488
TXNS112	188	94	282	34	37	30	383
TXNS 223	183	123	306	21	32	63	422
TXNS 278	217	102	319	33	42	26	421
AC88042-1	255	76	331	47	27	11	417
AC88165-3	193	33	226	56	29	33	344
Avalanche	279	75	354	48	55	66	523
A88338-1	210	100	311	22	31	16	380
AO89128-4	267	42	308	40	27	40	416
Mean	215	91	307	36	34	33	410
CV (%)	17	39	16	33	42	54	11
LSD (p = 0.05)	51	51	70	17	20	25	65

Red-skinned, Specialty, and Chipping Potato Variety Development, 1998

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Abstract

Red-skinned and specialty potato varieties constitute a small segment of the western states potato industry. Interest in specialty varieties will continue to remain focused on home gardens and small niche markets. However, interest in red-skinned varieties has continued to expand. Areas of the Skagit Valley in Washington, the Willamette Valley of Oregon, and several areas of California specialize in red-skinned potato varieties. The Western Regional Potato Variety Development Committee established a formal evaluation for red-skinned varieties in 1994 and for other specialty varieties in 1997. The Klamath Experiment Station (KES) has been involved with these evaluations since their inception. Because of limited interest in the Klamath Basin for specialty varieties, KES will discontinue the evaluation of these varieties. However, evaluation of red-skinned material will continue. Currently, two red-skinned selections, NDO2686-6R and NDO2438-6R, continue to show promise at all locations where they have been evaluated. Both produce medium-high yields of small to medium sized tubers with very attractive smooth, dark-red skin. Early generation seed of NDO2438-6R is currently being multiplied in California and prenuclear seed of NDO2686-6R will be distributed to several seed growers in 1999.

In recent years, acreage of chipping potatoes in the Klamath Basin has increased. Currently, around 3,000 acres of chipstock are grown annually in the basin. In review of the acreage increase, the KES felt the need to evaluate regional chip selections for local suitability.

Introduction

The KES began screening single-hill, first generation red-skinned seedlings from the North Dakota State University and Colorado State University breeding programs in 1988. The second-year screening was conducted at KES, while clones saved in the second year were provided to the Central Oregon Agricultural Research Center for further seed increase. Since the loss of aldicarb, it has been difficult to maintain freedom from Potato Virus Y during two years of production at KES. In 1998, the first-year screening program was transferred to Powell Butte to reduce risks of virus infection and also reduce the chance of introduction of root-knot nematodes from KES to the Powell Butte site.

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Standard red-skinned potato varieties currently available lack preferred quality characteristics of discerning buyers. Most standard varieties possess deep eyes, irregular shape, faint red skin, or a combination of these traits. The Oregon red-skinned variety development program has emphasized shallow eyes, round shape, and deep red skin. Because a portion of red-skinned varieties are stored, new selections should also retain color in storage.

Specialty varieties don't seem to have difficulty meeting quality criteria, mainly because of limited exposure. Specialty variety development continues to look for dark yellow flesh with varying skin colors. Standard chipping varieties are adequate in most aspects, but improvements in disease resistance, processing quality, and storability are needed. Primary emphasis has been placed on varieties that produce acceptable chip color from cold storage. Most chipping varieties are stored at 50 °F to minimize reducing sugars. Storage rots, excessive shrinkage, and sprouting are accelerated under high temperature storage. Varieties that produce acceptable chip color from 40-45 °F would allow more flexibility in storage management.

The 1998 KES program included 21 second-year, 12-hill selections, 6 third-year, 50-hill selections, 5 advanced clones in a replicated yield trial, and 3 standard varieties and 10 selections in the regional red trial. The specialty trial evaluated 5 standard varieties and 3 selections. Two standard varieties and 5 selections were included in the regional chip trial.

Procedures

All KES red-skinned, specialty, and chipping evaluations were conducted on a Poe fine sandy loam soil in a 4-year rotation with spring cereals, sugarbeets, and spring cereals. Telone II was applied at 18 gpa in November, 1997 to control nematodes and related diseases. All fertilizer for these trials (1,000 lb/acre 16-8-8-14) was banded at planting. Potatoes were planted with a two-row, assisted-feed planter in 32-inch rows on June 9. Seed was spaced at 8.7 inches. Cultural practices for irrigation, weed, insect, and disease control were as described for other variety trials. Potatoes in 12- and 50-hill screening trials were harvested with a two-row, level-bed digger on October 2. A one-row digger-bagger was used to harvest potatoes in replicated yield trials. Advanced reds were harvested on October 2 and specialty and chipping lines were harvested on October 7. All tubers from each plot were saved for grading. Samples were graded in mid- to late October.

Results and Discussion

Multi-hill Observational and Advanced Red-skinned Trials

None of the 12-hill selections were saved for further evaluation, primarily because of viral infection. Two of the 50-hill selections, NDO6183-1 and NDO6184-1, were saved for further evaluation. Six to eight tubers of these clones have been increased at Powell Butte. The clones will be evaluated in replicated yield trials at

KES and two California sites in 1999. Four of the advanced selections were retained for further evaluation. AO92655-9 and NDO5464-3 were dropped because of excessive storage rot problems.

Western Regional Red-skinned Trial

Given the wet spring and a five-week planting delay after seed cutting, all entries achieved acceptable emergence (Table 1). Final plant stands exceeded 90 percent in all selections except NDO4323-2R. All entries rated higher than Red LaSoda in skin color and eye depth. NDO4588-5R, NDO2438-6R, and NDO2686-4R were among the earliest in vine maturity.

Most entries had similar total yields as the standards (Table 2). Only NDO5437-7R and AO92655-9R were significantly lower in total yield than the three standards. As observed in numerous previous trials, NDO2686-4R produced high yields of Bs (<4 oz) and No. 1s <10 oz. In this trial, its yield of No. 1s <10 oz exceeded Red LaSoda yield <10 oz by 240 cwt/acre. Entries A79543-4R and NDO2686-4R produced 114 cwt/acre and 151 cwt/acre of <4 oz tubers, respectively. As usual, Red LaSoda and Dark Red Norland produced a high proportion of large tubers. Red LaSoda, Sangre, NDO4323-2R, and DT6063-1 led all entries in cull tonnage. Internal quality was generally good except for Sangre, A79543-4R, and DT6063-1R, which had 15, 25, and 25 percent hollow heart, respectively.

Three selections, COO86107-1R, DT6063-1R, and NDO2438-6R, completed three years of evaluation and have graduated from the trial. Oregon has decided to drop COO86107-1R. Colorado State University (CSU) officially released DT6063-1R as Cherry Red in February, 1999. This selection has been grown commercially under this name for several years. Oregon plans to pursue the release of NDO2438-6R. Remaining selections in the 1998 official regional trial will be evaluated again in 1999. The Oregon selection, NDO4300-1R performed particularly well in its first year in this trial. Sangre will be discontinued as a standard because of its slow emergence and late maturity.

Oregon is planning to release NDO2686-6R (not tested in regional trials in 1998) and NDO2438-6R. Both produce medium to high yields of small to medium sized tubers with extremely attractive smooth, dark red skin. CSU is also planning to release CO86218-2 in the near future. This selection has been evaluated in the regional trial and was grown commercially in Colorado in 1998. Industry found it satisfactory and will evaluate it again in 1999.

Western Regional Specialty Trial

Most of the entries in the specialty trial were yellow-fleshed with the exception of NDC4069-4R/R, which has dark-red flesh, and Crispen, which is white-fleshed (Table 3). Crispen, German Butter Ball and Red Gold produced the highest yields, while NDC4069-4R/R and AO90319-1 had the lowest yields (Table 4). German Butter Ball produced the highest yield of <4 oz tubers, while Yukon Gold produced the lowest. All entries had relatively low yields of culls and internal defects were minimal. Because of limited interest in the Klamath Basin for specialty varieties, KES will discontinue the specialty evaluation.

Western Regional Chipping Trial

This was the first year KES participated in the regional chipping trial. The trial included Atlantic and Chipeta as standards and 5 selections. A90467-14, a selection from Idaho, produced a significantly higher total yield than Atlantic and Chipeta (Table 5). The Oregon selection, AO91812-1, was significantly higher in total yield of U.S. No. 1s than Chipeta. All entries had relatively high specific gravity except AC87340-3. Atlantic, Chipeta, and A88431-1 had numerous growth cracks, which accounted for their higher yield of culls. Shatter bruise was noted as a problem for A88431-1 and A90467-14. Hollow heart and internal brown spot were observed in Atlantic and A88431-1. All other entries were relatively free of internal defects. Chip color was quite similar for all entries evaluated at KES and other cooperating sites.

After reviewing data from all locations, A88431-1 and AO91812-2 were dropped from further evaluation. A88431-1 was discarded because of excessive shatter bruise and internal brown spot problems. AO91812-2 was eliminated due to folded bud ends. The remaining entries will be evaluated again in 1999.

Summary

Late planting, high temperatures from mid-July through mid-September, and immature vines at harvest stressed most selections in these trials. Yields and quality were affected in several lines. However, several selections performed reasonably well under the difficult 1998 growing conditions. The Oregon program has several lines that appear to be worthy of release and capable of making a positive contribution to the potato industry of the western states.

Table 1. Plant and tuber characteristics of advanced, red-skinned potato selections grown at Klamath Falls, OR, 1998.

Variety/ selection	Percent stand 7/1	Percent stand 7/20	Vine vigor[1]	Vine maturity[2]	Tuber characteristics[3] Color	Eyes	Shape	Skinning
Red LaSoda	54	93	3.5	3.3	3.5	2.5	2.5	4.0
Dk. Red Norland	88	96	4.3	3.5	4.0	4.0	3.0	3.3
Sangre	28	98	3.0	5.0	4.0	3.0	2.0	2.0
A79543-4R	69	98	3.3	3.3	5.0	3.8	1.0	1.8
AO92657-3R	53	93	4.8	2.0	4.5	4.5	1.8	4.3
CO89097-2	68	94	4.3	3.3	4.5	5.0	2.0	4.5
COO86107-1R	79	98	4.0	3.0	4.8	4.5	2.0	4.0
DT6063-1R	63	98	3.5	4.0	4.3	5.0	3.0	4.0
NDO2438-6R	52	98	4.0	3.3	4.5	4.0	1.5	4.3
NDO2686-6R	47	95	4.5	3.0	4.8	4.3	1.0	4.3
NDO4300-1R	62	90	3.3	3.5	4.3	3.8	1.0	4.3
NDO4588-5R	92	94	3.5	2.8	4.8	3.0	1.8	4.3
NDO4592-3R	77	98	3.8	3.3	4.8	4.0	1.8	4.3
NDO3994-2R	76	91	3.3	3.5	4.0	3.8	3.0	3.3
NDO4323-2R	78	87	3.5	2.8	4.3	4.0	2.3	4.0
NDO5437-7R	68	98	3.8	1.8	5.0	5.0	5.0	5.0
NDO5464-3R	77	93	3.5	3.5	5.0	4.3	3.5	3.0
AO92655-9R	24	93	2.0	2.5	3.0	5.0	3.5	3.8
Mean	64	95	3.7	3.1	4.5	4.1	1.8	4.0

[1]/ Vine vigor rating: 1 is small and weak to 5 for large and robust.
[2]/ Vine maturity: 1 is early to 5 for a late maturing plant.
[3]/ Color rating: 1 is pale to pink to 5 for bright red.
Eyes depth: 1 is deep to 5 for shallow.
Shape: 1 is round, 2 for oval, 3 for oblong.
Skinning rating: 1 is severe to 5 for none.

Table 2. Yield, grade, tuber size distribution, and specific gravity of varieties and selections in the Western Regional Trial of red-skinned potatoes at Klamath Falls, OR, 1998

Variety/ selection	Yield No. 1s					Yield		Specific gravity
	< 4 oz	4-6 oz	6-10 oz	> 10 oz	total	culls	total	
	cwt/A							
Red LaSoda	34	61	89	130	313	146	459	1.070
Dark Red Norland	40	81	95	145	361	88	449	1.068
Sangre	27	69	95	116	307	102	410	1.078
A79543-4R	114	147	118	39	418	21	439	1.073
AO92657-3R	56	131	148	143	478	20	499	1.065
CO89097-2	60	114	131	138	443	48	491	1.076
COO86107-1R	39	86	114	104	343	68	412	1.077
DT6063-1R	40	74	71	159	345	102	447	1.080
NDO2438-6R	48	116	116	138	419	61	479	1.062
NDO2686-4R	151	180	93	28	453	18	470	1.070
NDO4300-1R	87	139	134	99	459	21	480	1.063
NDO4588-5R	39	81	100	157	377	63	440	1.060
NDO4592-3R	48	93	95	124	360	85	446	1.068
NDO3994-2R	88	120	92	46	346	51	396	1.067
NDO4323-2R	52	89	70	50	261	115	375	1.073
NDO5437-7R	141	75	10	1	227	6	233	1.069
NDO5464-3R	72	150	142	77	441	27	468	1.073
AO92655-9r	68	89	99	59	315	10	325	1.064
Mean	67	105	101	97	370	59	429	1.070
CV (%)	24	23	24	38	18	37	13	0.25
LSD (p = 0.05)	23	34	34	53	77	31	79	0.004

Table 3. Plant and tuber characteristics of specialty potatoes grown at Klamath Falls, OR, 1998.

Variety/ selection	Percent stand 7/1	Percent stand 7/20	Vine vigor[1]	Vine maturity[2]	Skin color	Flesh color	Tuber shape
Yukon Gold	42	84	2.5	3.3	yellow	yellow	ovate
German Butter Ball	94	98	4.8	4.3	yellow	yellow	round
Red Gold	89	96	4.8	3.3	red	yellow	oblong
NDC4069-4R/R	95	99	4.8	3.8	red	red	ovate
AO90319-1	63	99	3.5	4.3	brown	yellow	long
Day 9	54	97	2.0	3.3	yellow	yellow	oval
Crispin	98	100	4.0	4.5	buff	white	oval
Mean	76	96	3.8	3.8			

[1]/ Vine vigor rating: 1 is small and weak to 5 for large and robust.

[2]/ Vine maturity rating: 1 is early to 5 for late maturing plants.

Table 4. Yield, grade, tuber size distribution, and specific gravity of specialty potatoes grown at Klamath Falls, OR, 1998.

Variety/ selection	Yield No. 1s < 4 oz	4-6 oz	6-10 oz	> 10 oz	total	Yield culls	Yield total	Specific gravity
	cwt/A							
Yukon Gold	17	55	76	221	369	22	391	1.083
German Butter Ball	157	163	163	30	424	24	448	1.085
Red Gold	52	142	142	99	403	40	443	1.077
NDC 4069-4R/R	112	114	114	17	305	20	324	1.081
AO90319-1	103	130	130	14	305	20	325	1.083
Day 9	28	67	67	148	337	39	376	1.076
Crispin	43	134	134	115	461	9	470	1.083
Mean	73	115	115	92	372	25	397	1.081
CV (%)	19	23	23	36	18	52	16	0.2
LSD (p = 0.05)	21	40	40	50	85	20	90	0.003

Table 5. Yield, grade, tuber size distribution, specific gravity, and chip color of entries in the western regional chip trial grown at Klamath Falls, OR, 1998.

Variety/	Yield No. 1s			Yield			Specific	Chip
selection	4-12 oz	12 oz	total	Bs	culls	total	gravity	color[1]
	cwt/A							
Atlantic	196	104	300	42	36	377	1.089	2.0
Chipeto	213	84	296	20	67	383	1.084	2.0
A88431-1	250	74	325	51	55	431	1.095	3.0
AC87340-3	270	29	299	129	5	432	1.080	2.0
AO91812-1	303	76	379	47	6	432	1.091	2.0
AO91812-2	306	35	341	65	4	409	1.089	2.0
A90467-14	289	82	371	55	40	466	1.095	2.5
Mean	261	69	330	58	30	419	1.089	2.2
CV (%)	14	56	16	18	79	12	0.4	--
LSD (p = 0.05)	53	58	80	16	36	75	0.006	--

1/ Chip color: 1 is light to 5.0 for very dark

Evaluation of Clones of Russet Norkotah, Russet Burbank, and Shepody

K.A. Rykbost[1], B.A. Charlton[1], S.R. James[2], and D.C. Hane[3]

Abstract

Resistance to Potato Virus Y (PVY) was successfully inserted into clones of Russet Burbank, Russet Norkotah, and Shepody by genetic engineering techniques at Oregon State University (OSU) several years ago. Two years of evaluation of agronomic performance and challenging the clones with PVY, has reduced the number of transformed clones to two Shepody, three Russet Burbank, and four Russet Norkotah clones. Trials were conducted at Hermiston (HAREC), Central Oregon (COARC), and Klamath Falls (KES) in 1998 to compare the agronomic performance of these remaining selections with standard variety lots and with two Colorado and two Texas line selections of Russet Norkotah.

The 1998 trials completed eight location-years of agronomic performance (three years at HAREC and COARC and two years at KES) evaluations. After review of all data, one Russet Norkotah clone (NP3-138) and two Shepody clones (SH-RC4-124-1 and SH-RC4-129-1) will be advanced to the Tri-State trials in 1999. These selections have shown a high degree of resistance to PVY and have produced similar yields and quality to standard Russet Norkotah and Shepody at all locations. The Russet Burbank transgenic clones will be discarded. Their performance was inconsistent across locations and PVY resistance is less important for Russet Burbank which is less susceptible and expresses readily observed foliage symptoms.

Colorado and Texas Russet Norkotah line selections were inferior to the standard Russet Norkotah at KES and COARC. This was contrary to previous experience with these selections and was thought to be the result of late planting which was more detrimental to these later maturing selections than standard Norkotah. With high yields at HAREC, CORN-3 and TXNS223 were first and second in total yield of No. 1s, respectively, with standard Norkotah third. All four of the Norkotah line selections are under plant variety protection and currently constitute a major portion of Russet Norkotah seed production in Colorado.

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Introduction

Russet Norkotah and Shepody have become important varieties in the Pacific Northwest. Both are very susceptible to PVY but express poor foliar symptoms. Seed growers have difficulty rouging infected plants, leading to a rapid buildup of infection in seed lots. While these varieties are important for fresh market and French fry industries, they are causing problems for the seed industry. The availability of PVY resistance in these varieties through genetic engineering would be very beneficial to the industry. Seed of transformed selections of several commercially important varieties with PVY resistance is available from NatureMark®. PVY resistance has also been inserted by genetic engineering techniques in an OSU project. This report summarizes agronomic performance of OSU transformed clones in 1997 and 1998.

Procedures

OSU transformed clones, Colorado and Texas Russet Norkotah line selections, and standard lots of Russet Norkotah, Russet Burbank, and Shepody were evaluated in a KES completely randomized block design experiment with four replications. Seed was hand cut to 1.5 to 2.0 oz, treated with Tops MZ, and suberized and stored at approximately 50 °F and 95 percent relative humidity for four weeks before planting on June 8. All plots were single rows with 30 hills. Seedpieces were spaced at 8.7 inches in 32-inch rows. Other cultural practices are described on page 35.

Vines were desiccated with 1.0 pint/acre Diquat applied with a conventional ground sprayer on September 19. Tubers were harvested with a one-row digger-bagger on October 5. All tubers from each plot were stored and graded to USDA standards on October 22. Ten U.S. No. 1 tubers in the 8- to 12-oz size fraction from each plot were measured to determine width-to-length ratios. Yield, grade, specific gravity, and width-to-length ratio data were subjected to statistical analyses using MSUSTAT software. Similar procedures were followed at Powell Butte where planting date was June 4 and harvest date was October 20. At Hermiston, Russet Norkotah and Shepody lines were included in one trial planted on April 8, desiccated on July 29, and harvested on August 14. Russet Burbank lines were evaluated in a second trial planted on April 8, desiccated on September 14, and harvested on October 9. Standard cultural practices were followed at each site.

Results and Discussion

Rapid and uniform emergence resulted in plant stands of 96 to 99 percent within 30 days of planting at KES (Table 1). Canopy vigor was similar among standard and transformed clones in all varieties. The line selections from Colorado were slower to develop full canopies, but were clearly later in maturity, as has been observed in all tests of these selections.

At KES and COARC, Russet Norkotah lines experienced a significant incidence of hollow heart in large tubers. Transformed clones and line selections were not significantly different from the standard in incidence of hollow heart. Hollow heart was minimal in Russet Norkotah at HAREC, but Russet Burbank clones had a minor incidence of both hollow heart and brown center. Shepody selections were relatively free from internal defects at all locations.

Specific gravity was similar for transformed and standard lines at all locations. Length-to-width ratios were similar for Russet Norkotah and Russet Burbank clones. At KES and COARC, Shepody transformed clones had significantly longer tuber type than standard Shepody.

As in other 1998 KES experiments, yields were quite variable as evidenced by high coefficients of variability (Table 2). Total yield of U.S. No. 1s were not significantly different even though CORN-3 and CORN-8 produced 102 and 114 cwt/acre less than the standard Russet Norkotah, respectively. Both Colorado selections and all transformed Norkotah clones had significantly lower yields of large No. 1s than the standard Norkotah at KES. Yields and size distribution were similar for transformed clones and Russet Burbank and Shepody standards.

Total yields, percent No. 1s, and total No. 1 yields are shown for transgenic and standard lots for 1997 and 1998 at all locations in Table 3. Among Russet Norkotah clones, NP3-138 produced yields nearly equal to the standard Norkotah at KES and COARC. This clone was highly resistant to PVY when challenged with the virus at Hermiston. The clone will be entered in the Tri-State trials in 1999. N43-191 achieved the highest yield of Norkotah clones at HAREC, but is not highly resistant to PVY. It was lowest in yield at COARC.

All transformed Russet Burbank clones produced lower yields of No. 1s than the standard at HAREC and COARC. At KES, the clones were slightly higher in No. 1 yield than the standard. PVY is not as serious a problem for Russet Burbank as for Russet Norkotah and Shepody. Since none of the clones performed as well as the standard in the long-season Hermiston area, a decision was made to discontinue evaluation of these lines.

Both transformed Shepody clones were equal to the standard Shepody in total No. 1 yield at all locations. These clones will be entered in the 1999 Tri-State trials for further evaluation.

Summary

Russet Norkotah and Shepody are currently the second and third largest varieties in acreages of potato production in North America. The effects of seedborne PVY on yields and economic returns for Russet Norkotah and Shepody have been well documented in previous research at KES, HAREC, Tulelake, California, and in Idaho. Both varieties mask PVY symptoms, resulting in undetected buildup of virus infections in seed crops. The availability of transformed clones with excellent PVY resistance and comparable agronomic performance would be very beneficial for commercial and seed production of these varieties. Even if yields were 5 to 10 percent lower for resistant lines, the transformed clones would provide economic benefits.

OSU holds a patent on the gene construct used to insert PVY resistance. A genetic marker gene and a promoter used in the transformation are under a private patent. If further evaluation results in a decision to release one or more of the clones, OSU and the holder of the private patents will have to arrange an agreement on ownership of the material.

Table 1. Characteristics of Russet Norkotah, Shepody, and Russet Burbank transgenic clones and standard varieties and Russet Norkotah line selections grown at Klamath Falls, OR, 1998.

Variety/ selection	Plant stand	Vine vigor[1]	Hollow heart	Specific gravity	Length/width ratio
	%		%		
Russet Norkotah	99	4.0	15	1.071	1.92
N12-024	98	3.8	23	1.067	1.88
N43-191	98	3.5	30	1.069	2.03
NP2-020	98	3.8	8	1.075	1.95
NP3-138	98	4.0	18	1.070	1.95
CORN-3	96	3.0	3	1.077	1.82
CORN-8	98	2.8	8	1.072	1.88
TXNS 112	97	4.0	10	1.071	1.81
TXNS 223	96	3.0	12	1.070	1.85
Russet Burbank	98	4.8	13	1.084	2.17
R40-007	97	5.0	5	1.081	2.13
R46-455	96	4.8	0	1.084	2.19
R46-456	99	5.0	0	1.085	2.33
Shepody	97	3.8	3	1.081	1.70
SH-RC4-124-1	97	4.0	3	1.079	1.97
SH-RC4-129-1	97	4.0	0	1.077	1.94
Mean	97	4.0	10	1.076	1.97
CV (%)			124	0.3	5
LSD (p = 0.05)			17	0.004	0.15

[1/] Vine vigor rating: 1 is small and weak to 5 for large and robust

Table 2. Yield and grade of Russet Norkotah, Russet Burbank, and Shepody clones grown at Klamath Falls, OR, 1998.

Variety/ selection	Yield U.S. No. 1s			Yield			
	4 -12 oz	>12 oz	total	Bs	No. 2s	culls	total
	cwt/A						
Russet Norkotah	213	169	382	25	32	24	463
N12-024	266	103	369	37	26	10	442
N43-191	201	115	316	27	34	17	394
NP2-020	225	80	305	36	10	3	354
NP3-138	254	82	336	60	12	10	418
CORN-3	202	78	280	31	34	13	357
CORN-8	176	93	268	21	49	22	360
TXNS 112	175	137	312	24	38	29	403
TXNS 223	184	130	314	22	41	28	405
Russet Burbank	230	50	279	56	50	53	438
R40-007	234	50	284	75	51	18	428
R46-455	273	40	313	62	52	33	460
R46-456	276	53	329	48	38	17	432
Shepody	212	81	293	29	34	12	368
SH-RC4-124-1	215	89	303	32	40	17	392
SH-RC4-129-1	196	105	301	31	57	19	407
Mean	221	91	312	39	37	20	407
CV (%)	20	39	20	51	47	61	16
LSD (p = 0.05)	62	50	NS	28	25	18	NS

Table 3. Yield and percentage of No. 1s for transgenic Russet Norkotah, Russet Burbank, and Shepody clones grown at HAREC, COARC, and KES, 1997 - 98.

Variety/ selection	Parameter	HAREC			COARC			KES			Overall mean
		1997	1998	Mean	1997	1998	Mean	1997	1998	Mean	
Russet Norkotah	Total yield[1]	514	413	464	355	375	365	511	463	487	439
	% No. 1s	71	83	77	83	75	79	85	83	84	80
	Total No. 1 yield	364	341	353	296	283	290	435	382	409	351
N12-024	Total yield	522	238	380	282	357	320	501	442	472	391
	% No. 1s	70	82	76	82	81	82	89	83	86	81
	Total No. 1 yield	364	194	279	232	290	261	446	369	408	303
N43-191	Total yield	577	331	454	283	312	298	512	394	453	402
	% No. 1s	74	82	78	80	69	75	88	80	84	79
	Total No. 1 yield	425	273	349	227	215	221	449	316	383	318
NP2-020	Total yield	515	293	404	297	370	334	461	354	408	364
	% No. 1s	63	77	70	74	82	78	83	86	85	78
	Total No. 1 yield	326	225	276	219	302	262	382	305	344	294
NP3-138	Total yield	508	233	371	352	376	364	529	418	474	403
	% No. 1s	56	76	66	79	77	78	89	80	85	76
	Total No. 1 yield	286	177	232	278	288	283	469	336	403	306

Table 3. (continued) Yield and percentage of No. 1s for transgenic Russet Norkotah, Russet Burbank, and Shepody clones grown at HAREC, COARC, and KES, 1997 - 98.

Variety/ selection	Parameter	HAREC 1997	HAREC 1998	HAREC Mean	COARC 1997	COARC 1998	COARC Mean	KES 1997	KES 1998	KES Mean	Overall mean
Russet Burbank	Total yield	549	713	631	534	379	457	430	438	434	507
	% No. 1s	60	38	49	62	60	61	70	64	67	59
	Total No. 1 yield	327	271	299	330	229	280	299	279	289	289
R40-007	Total yield	491	712	602	425	393	409	415	428	422	478
	% No. 1s	49	38	44	52	56	54	75	66	71	56
	Total No. 1 yield	242	270	256	223	222	223	310	284	297	259
R46-455	Total yield	555	719	637	417	374	396	488	460	474	502
	% No. 1s	51	38	45	64	67	66	68	68	68	60
	Total No. 1 yield	284	270	277	267	250	259	330	313	322	286
R46-456	Total yield	567	824	696	376	417	397	462	432	447	513
	% No. 1s	52	31	42	59	66	63	69	76	73	59
	Total No. 1 yield	297	258	278	223	276	250	317	329	323	284
Shepody	Total yield	464	553	509	361	321	341	497	368	433	428
	% No. 1s	88	92	90	63	48	56	80	80	80	75
	Total No. 1 yield	406	506	456	229	154	192	400	294	347	332
SH-RC4-124-1	Total yield	503	530	517	314	371	343	552	392	472	444
	% No. 1s	88	92	90	60	66	63	77	77	77	77
	Total No. 1 yield	444	490	467	189	244	217	426	303	365	350
SH-RC4-129-1	Total yield	573	573	573	352	385	369	487	407	447	463
	% No. 1s	85	89	87	58	52	55	70	74	72	71
	Total No. 1 yield	487	512	500	204	201	203	342	301	322	342

[1/] Yields are in cwt/acre.

Effects of Seedpiece Treatment with Fungicides on Russet Norkotah, 1998

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Abstract

Two experiments conducted at KES in 1998 evaluated effects of several fungicide seed treatments on performance of Russet Norkotah. One trial, unique to KES, failed to detect significant effects on total or total No. 1 yields among seven seedpiece treatments and an untreated control. Average yields in this trial were approximately two-thirds of yields observed in a very similar experiment with Russet Norkotah in 1997. Evaluation of tubers within a week of harvest did not detect treatment effects on the incidence of *Rhizoctonia solani* (Rhizoctonia) or *Helminthosporium solani* (silver scurf). None of the treatments significantly affected timing of plant emergence or final plant stands.

A second experiment, including four of the same fungicide treatments and five additional treatments, was conducted at KES, Hermiston, Powell Butte, and Othello, WA sites. Yields were not significantly affected by any of the treatments at KES. Tuber samples were incubated under controlled conditions at Hermiston. Averaged over all locations, Maxim, Tops MZ (16 oz/cwt), Tops MZ (12 oz/cwt), and Quadris treatments reduced the incidence and severity of silver scurf after short-term incubation compared with Tops 5, Dithane, Sorbic Acid Potassium Salt Dust, Sodium Carbonate Dust, and an untreated control. Evaluations of silver scurf incidence and severity after 6-month storage are incomplete.

Introduction

Control of seedborne fungal diseases has become a greater concern in recent years for several reasons. Russet Norkotah seems to be more susceptible to silver scurf than Russet Burbank, which Norkotah has largely replaced in the Klamath Basin. Silver scurf has developed resistance to previously effective control measures used on stored crops. New, more virulent strains of *Phytophthora infestans* (late blight) have become established in all production areas of the northwest, including the Klamath Basin. Rhizoctonia causes stand and tuber quality losses when favorable conditions such as cool, wet spring weather occur. New seed-treatment fungicides are being developed to protect crops from these

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diseases. Recent research in several production regions has demonstrated suppression of silver scurf with Maxim and mancozeb products. One recent family of products offered for evaluation includes cymoxanil in the formulations. This fungicide reportedly has some curative activity against late blight and may protect against seedborne late blight spread during seed cutting and handling.

Procedures

Seed treatment fungicides were evaluated on Russet Norkotah in two separate randomized complete block design experiments with four replications. Trial I used a Klamath County Generation III seed lot with no visible symptoms of silver scurf. Tubers were hand cut to 1.5- to 2.0-oz seedpieces on May 7. Cut seed batches of 50 lb were treated with appropriate quantities of 7 products and mixed several times between containers to achieve uniform product distribution on seedpieces. One batch was left untreated. All lots were isolated from each other and allowed to suberize at about 50 °F and 95 percent relative humidity. Because planting was delayed by wet soil conditions, seed was held under these conditions for 33 days. Seedpieces were counted and bagged in paper for individual plot rows on June 4. Individual plots were two rows of 30 hills each.

Seed for Trial II was Generation III Russet Norkotah with a very high level of silver scurf infection. The same seed lot was used for all locations of the experiment. Seed was hand-cut and batch treated as described above except that the PCNB treatment was applied in the seed furrow at planting. Both experiments were planted with an assisted-feed, two-row planter on June 9. Seed was spaced at 8.7 inches in 32-inch rows. Fertilizer was banded at 1000 lb/acre of 16-8-8-14 at planting. Other cultural practices are described on page 35.

Vines were desiccated with Diquat applied at 1 pt/acre on September 19. Trial I tubers were harvested on October 5. All tubers from each plot were weighed in the field. Approximately 120 lb/plot were stored and graded to USDA standards on October 16. With no visual evidence of silver scurf, infection ratings were not made.

Tubers were harvested from Trial II on October 12. All tubers were weighed in the field at harvest. Two 25-tuber subsamples were saved from each plot and delivered to HAREC for pre- and post-storage evaluation of silver scurf infections. Remaining tubers were graded to USDA standards at KES on October 13. Yields were adjusted in both trials to account for ungraded tubers, assuming uniformity of grades between graded and ungraded portions of tubers.

Tuber subsamples from Trial II were delivered to Hermiston two days after harvest. One subsample from each plot was immediately placed in incubation at 20 °C for three weeks at high relative humidity in darkness. Evaluations after incubation determined the percent of tubers with silver scurf infections and the percent of tuber surface infected. A disease symptom index was calculated as the mean percentage of infection for all tubers. The second subsample was placed in storage typical of commercial storage to be evaluated after 6 months.

Results and Discussion

Product application rates and plant emergence data are presented for both trials in Tables 1 and 2. Final stands ranging from 90 to 96 percent were not significantly different. A delay in emergence noted in LS130 in a 1997 trial was again apparent in Trial I but was less pronounced in 1998. The 33-day delay between seed cutting and planting did not affect seed performance differentially among treatments. Canopy development was not affected by seed treatments. No differences were observed in vine vigor, vine maturity, incidence of hollow heart in large tubers, or specific gravity (data not presented).

In Trial I, yield differences among treatments were generally minor (Table 3). Differences were only significant at the 5 percent probability level for yield of No.1s over 12 oz and yield of Bs (<4 oz). At the 10 percent probability level, total yield of No.1s was significantly higher for Maxim (fludioxonil) and Mancozeb treatments than for Tops 5.0 (thiophanate-methyl) and LS130. All other treatments produced similar total No.1 yields. In a similar trial in 1997, none of the treatments affected total No.1 yields (Table 4).

Effects of growing season conditions are very evident when yields between seasons are compared (Tables 3 and 4). The average yield of No. 1s in 1998 was 64 percent of yields observed in the 1997 trial. Although total yields were much lower in 1998, the yield of No. 2s and culls was higher than in 1997 across all treatments. Heat stress from 29 days with maximum air temperatures exceeding 90 °F resulted in some tuber deformities and a higher incidence of hollow heart in large tubers than in 1997.

Similar total and total No. 1 yields were observed in Trial I and Trial II (Tables 3 and 5). No significant differences were observed for any yield components at the 5 percent probability level in Trial II. Tubers were considerably smaller in Trial II than in Trial I. Yields of Bs (<4 oz) and 4- to 8-oz No. 1s were higher and yield of >12 oz No. 1s was less in Trial II. Yield of No. 2s and culls were similar in both trials. Differences in tuber size were probably caused by seed lot influence. In all other respects, the trials experienced uniform management.

Tubers from all sites were evaluated at HAREC for silver scurf infection in pre- and post-storage incubations. Infection levels and severity were very similar between Hermiston and KES in pre-storage evaluations (Table 6). Percentage of infected tubers were about three times greater at Central Oregon and Washington sites. Averaged over locations, Maxim plus PCNB was significantly lower in disease symptom index than all other treatments. Maxim, Tops MZ, Quadris (azoxystrobin), and the 12 oz /cwt rate of Tops MZ were significantly lower in disease symptom index than the untreated check, Dithane, Sorbic Acid, and Sodium Carbonate. The interaction between treatment effects and location was significant for infection levels and severity. However, in general the Maxim, Tops MZ, and Quadris treatments were quite effective in reducing silver scurf infection while Tops alone, Dithane, Sorbic Acid, and Sodium Carbonate were ineffective. Post-storage evaluations of silver scurf infections are not completed.

Summary

There is increased concern for seed transmission of potato late blight. While late blight was not investigated in these trials, research elsewhere has demonstrated efficacy against late blight for several of the materials evaluated. The LS products included in the trials are formulations including Tops, Mancozeb, and Curzate (cymoxanil). They are believed to offer protection against transmission of late blight during seed handling. Mancozeb products also provide some protection from late blight in cut seed. Several of the products evaluated in 1997 and 1998 trials have demonstrated efficacy against silver scurf. Maxim and Tops MZ provided good control of silver scurf in trials in 1997 and 1998. Quadris was also effective in the 1998 trial. Industry continues to make progress in developing effective seed treatment products for fungal diseases in potatoes. In KES trials, these products have been shown to produce equivalent yields to standard seed treatments and untreated checks.

Table 1. Emergence of plants in Russset Norkotah seed treatment Trial I at Klamath Falls, OR, 1998.

Treatment	Product rate	Emergence 6/30	7/3	7/8
	lb/cwt		%	
Untreated check	0	45	69	93
Maxim	0.5	31	67	92
Mancozeb 6%	1.0	40	75	93
Tops MZ	1.0	34	70	94
Tops 5.0	0.5	44	76	96
LS 130	0.5	29	63	92
LS 214	0.5	44	78	94
LS 209	0.5	45	73	93
Mean		39	71	93

Table 2. Emergence of plants in Russet Norkotah seed treatment Trial II at Klamath Falls, OR, 1998.

Treatment	Product rate	Emergence 6/30	7/3	7/8
	lb/cwt		%	
Untreated check	0	68	89	96
Maxim	0.5	61	81	91
Maxim +	0.5	75	88	95
PCNB[1]	1.65			
Mancozeb 8%	1.0	52	77	91
Quadris	0.5	73	83	96
Tops 5.0	0.5	64	88	96
Tops MZ (16 oz/cwt)	1.0	66	80	90
Tops MZ (12 oz/cwt)	0.75	68	82	92
Sorbic acid K salt	1.0	66	83	93
Sodium carbonate	1.0	61	77	90
Mean		65	83	90

1/ PCNB applied in the seed furrow at 1.65 lb/1000 feet of row

Table 3. Effects of seedpiece fungicides on yield, grade, and tuber size distribution of Russet Norkotah grown at Klamath Falls, OR, 1998, Trial I.

Treatment	Yield U.S. No. 1s 4-8 oz	8-12 oz	>12 oz	total	Yield Bs	No. 2s	culls	total
	cwt/A							
Untreated check	126	90	105	321	36	26	22	405
Maxim	133	102	111	346	29	23	19	417
Mancozeb 6%	121	103	132	356	31	21	23	431
Tops MZ	116	90	127	332	30	30	19	410
Tops 5.0	129	75	91	294	44	23	17	378
LS 130	120	86	85	291	35	36	20	381
LS 214	132	85	106	323	42	26	9	400
LS 209	127	88	107	322	27	26	28	403
Mean	125	90	108	323	34	26	20	403
CV (%)	12	11	20	9	20	34	52	8
LSD (p = 0.05)	NS	14	NS	NS	10	NS	NS	NS

Table 4. Effects of seedpiece fungicides on yield, grade, and tuber size distribution of Russet Norkotah grown at Klamath Falls, OR, 1997.

Treatment	Yield U.S. No. 1s 4-8 oz	8-12 oz	>12 oz	total	Yield Bs	No. 2s	culls	total
	cwt/A							
Untreated check	157	194	146	497	39	28	19	583
Maxim	169	219	122	509	41	12	7	569
Mancozeb 8%	137	200	151	488	29	16	15	547
Tops MZ	157	204	145	506	35	14	5	560
Tops 2.5	163	202	137	502	44	31	7	583
Tops 5.0	170	207	142	518	42	9	2	571
LS 130	132	206	167	505	32	19	16	572
LS 132	101	174	236	511	26	25	15	576
Mean	148	201	156	505	36	19	10	570
CV (%)	15	13	24	6	21	56	82	4
LSD (p = 0.05)	34	NS	55	NS	11	NS	NS	NS

Table 5. Effects of seedpiece fungicides on yield, grade, and tuber size distribution of Russet Norkotah grown at Klamath Falls, OR, 1998, Trial II.

Treatment	Yield U.S. No. 1s 4-8 oz	8-12 oz	>12 oz	total	Yield Bs	No. 2s	culls	total
	cwt/A							
Untreated check	183	67	52	302	63	41	14	420
Maxim	150	78	63	291	58	30	10	389
Maxim +PCNB	204	77	68	349	69	22	14	454
Mancozeb	186	85	55	326	64	22	16	427
Quadris	182	77	73	332	52	26	19	429
Tops 5.0	208	75	29	312	85	21	16	434
Tops MZ (16 oz/cwt)	163	72	102	337	62	19	17	435
Tops MZ (12 oz/cwt)	188	69	89	346	76	27	5	454
Sorbic acid K salt	174	55	44	273	73	34	16	396
Sodium carbonate	196	76	36	308	78	25	17	428
Mean	184	73	61	317	68	27	14	426
CV (%)	14	27	60	14	25	57	87	12
LSD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS

Table 6. Effects of seed treatment fungicides on Silver Scurf infection levels and severity in Russet Norkotah grown at Klamath Falls, (KES), Powell Butte (COARC), and Hermiston (HAREC), OR, and Washington State University (WSU), WA, 1998.

	Percent of tubers with symptoms[1]					Disease symptom index[2]				
Treatment	KES	COARC	HAREC	WSU	Mean	KES	COARC	HAREC	WSU	Mean
Untreated check	14.0 bcde[3]	52.2 b	16.7 bcd	32.0 b	28.7 bc	3.8 bcd	15.5 b	5.0 bc	8.8 ab	8.3
Maxim	1.0 a	20.5 a	9.5 abc	19.0 a	12.5 a	0.2 a	5.3 a	1.9 ab	5.4 a	3.2
Maxim +PCNB	3.2 ab	9.0 a	1.1 a	---	10.3 a	0.6 ab	1.8 a	0.2 a	--	0.9
Mancozeb	22.7 de	50.0 b	23.4 d	28.0 ab	31.0 c	5.8 d	13.4 b	6.7 c	8.0 ab	8.5
Quadris	3.0 ab	9.9 a	8.5 ab	22.0 ab	10.8 a	0.8 ab	4.4 a	1.9 ab	5.6 a	3.2
Tops 5.0	19.0 cde	53.6 b	21.8 d	35.0 b	32.3 c	4.2 cd	13.1 b	5.1 bc	11.0 b	8.4
Tops MZ (16 oz/cwt)	10.3 abcd	14.4 a	9.5 abc	25.0 ab	14.8 a	2.1 abc	3.1 a	3.4 abc	8.2 ab	4.2
Tops MZ (12 oz/cwt)	7.0 abcd	14.0 a	9.5 abc	21.0 a	12.9 a	1.6 abc	3.0 a	2.7 ab	5.4 a	3.2
Sorbic Acid K Salt	17.3 cde	45.0 b	10.8 abc	21.0 a	23.5 b	5.7 d	13.2 b	2.4 ab	6.0 a	6.8
Sodium Carbonate	25.3 e	55.7 b	11.5 abcd	30.0 ab	30.6 c	7.0 d	15.5 b	3.0 ab	8.6 ab	8.5
Mean	12.3 a	32.4 c	12.2 a	26.1 b	20.8	3.2 a	8.8 c	3.2 a	5.7 b	5.2

1/ Average percentage of tubers showing symptoms after 3 weeks incubation at 20 °C in darkness at high humidity.

2/ Formula based on percentage of tuber surface showing symptoms after 3 weeks incubation at 20 °C in darkness at high humidity.

3/ Means followed by the same letter are not significantly different at p=0.05 based on Duncan's Multiple Range Test.

Spring Barley Variety Screening, 1998

R.L. Dovel[1], R.S. Karow[2], and G. Chilcote[1]

Introduction

Spring barley accounts for about 80 percent of cereal crops grown on over 100,000 acres in the Klamath Basin. Both feed and malting types are important in the region. Barley variety trials planted at the Klamath Experiment Station (KES) in 1998 included the Western Regional Spring Barley trial in cooperation with western states plant breeders, early variety screening of barley stripe rust (BSR) resistant lines, and a statewide barley trial. The statewide trial is a collection of new varieties and promising lines from public and private breeding programs.

Procedures

All small grain variety trials at KES were on land planted in potatoes the previous year. Soils at the station include Poe, Fordney, and Hosley series, all of which have a fine-loamy to sandy texture, are moderately deep, and somewhat poorly drained. All plots were sprinkler irrigated. Barley trials were arranged in a randomized, complete-block design with either three or four replications. Plots were planted on April 30. Seed was planted to a depth of 1 inch. The Oregon Statewide Variety trial had a seeding rate of 30 seeds/ft^2. All other trials have a seeding rate of 100 lb/acre. All plots were fertilized with 20 lb N, 12 lb P_2O_5, and 9 lb S/acre at time of seeding. Additional fertilizer was broadcast before planting at 80 lb N, 48 lb P_2O_5, and 35 lb S/acre. Plots measured 5 × 20 feet, with a row spacing of 6 inches (10 rows). Bromoxynil and MCPA were applied at labeled rates to control broadleaf weeds. Plots were harvested in mid September using a plot combine with a 5-foot wide header. Grain yield was recorded for all plots. Test weight, percentage of plumps, and percentage of thins were measured in only one replication.

Results and Discussion

OSU Spring Barley Trial

Two 2-row lines, BZ594-19 and C32, were the highest producing entries in the trial. Two-row varieties had lower BSR infection than six-row lines. The most commonly planted six-row varieties, Steptoe, Gustoe, and Gus, had 83, 67, and 63 percent infection, respectively (Table 1). Fifteen entries had less than 10 percent BSR infection. Many of these lines have been selected for BSR resistance. Orca is a 2-row feed barley developed by OSU. It produced the third

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highest grain yield in the trial and only had 1 percent BSR infection. Orca is stiff strawed and has proven to be lodging resistant, even under irrigation. Tango is a BSR resistant, Steptoe-derived, 6-row feed barley developed by OSU. It produced grain yields not significantly different than the top producing entries. Tango is agronomically very similar to Steptoe and yielded within 10 lb of Steptoe with a test weight of 50 lb/bu compared to 48.1 lb/bu for Steptoe. Tango is as prone to lodging as Steptoe and should be managed accordingly. Bancroft is a 2-row malt type that is BSR resistant (1 percent BSR infection in this trial), but it is tall and susceptible to lodging. Two 6-row, BSR-resistant lines developed by UC Davis are UC 958 and UC 960. Both have produced good yields at KES and have had a low BSR infection, but test weights were low in this trial.

Chinook, a new 2-row variety had only 1 percent BSR infection and produced yields equivalent to the top producing lines in both 1997 and 1998. Seed of Chinook may be available in small quantities; however, it should be noted that this variety lodged severely in 1997. Although B 1202 had 14 percent BSR infestation, it yielded 4430 lb/acre and was widely planted in the Klamath Basin in 1998.

BSR has been an important factor in barley yield in the region for the past three years. Several varieties, with better resistance to BSR than commonly grown varieties such as Steptoe and Coulter, have also produced higher yields over that period. Baronesse has been the leading producer over a 3-year period, followed by Idagold, B 1202, Galena, and Bancroft (Table 2). Old time leaders such as Steptoe, Gus, and Gustoe are now the lowest yielders over a three-year period.

BSR is a changeable organism: resistance to the disease in one year does not guarantee resistance in following years. What we currently have in commercially available spring barley varieties is best described as a gradient from less susceptible lines to very susceptible lines. Choosing varieties that have shown less disease expression in the past may result in less disease in subsequent years. However, vigilant scouting programs should be followed and application of foliar fungicides may be necessary until truly resistant lines are commercially available.

Western Regional Spring Barley Nursery

Nine entries were not significantly lower yielding than WA 10494-93, the highest yielding entry in the trial (Table 3). TR 139, Klages, Harrington, TR 128, WPB BZ594-19, UT 5724, TR 133, B 1202, and WA 9504-94 produced significantly higher yields than Steptoe. Top yielding varieties over the last two years include WPB BZ594-19, TR 128, Harrington, and TR 139 (Table 4). Over a three-year period, TR 139 was the highest yielding entry followed by TR 133 and TR 128 (Table 4).

Table 1. OSU Spring Barley Trial, Oregon Statewide Variety Testing Program, irrigated mineral soil site: agronomic and quality data of spring barley varieties and lines established April 30 at KES, Klamath Falls, OR, 1998.

Entry	Variety	Market Class[1]	BSR[2]	Yield	Test wt	Protein	Lodging	Height	50% heading
			%	lb/A	lb/bu	%	%	inches	Julian
1	Orca	2RF	1	4940	54.1	11.7	0	31	185
2	Tango	6RF	1	4720	50.0	10.4	5	33	183
3	BCD 12	2RF/M	2	3890	50.8	11.7	0	23	190
4	BCD 22	2RF/M	6	4400	52.6	12.0	0	24	190
5	BCD 47	2RF/M	1	4140	52.6	12.4	0	20	190
6	Baronesse	2RF	9	4730	51.4	11.1	13	29	188
7	Steptoe	6RF	83	4710	48.1	9.8	0	31	184
8	H 3860244	-	1	4730	52.6	11.9	0	33	188
9	MT 920073	-	3	4750	53.8	11.4	0	30	188
10	Chinook	2RM	1	4860	53.3	11.7	0	30	190
11	Gallatin	2RF	16	4720	52.7	11.0	0	32	187
12	Bancroft	2RM	2	4670	52.0	11.3	25	33	189
13	UC 958	6RF	2	4120	46.6	11.4	0	21	184
14	UC 960	6RF	4	4160	46.6	11.4	0	22	184
15	Galena	2RM	7	4400	52.1	11.6	0	28	191
16	Idagold	2RF	18	4800	50.8	11.8	0	22	191
17	C32	2RM	6	5030	52.2	11.3	0	25	190
18	BZ594-19	2RF	6	5690	52.5	10.7	0	30	187
19	Gus	6RF	63	3470	46.3	11.1	0	21	188
20	Gustoe	6RF	67	3760	45.9	10.9	0	23	187
21	B1202	2RM	14	4430	50.9	12.0	0	32	190
22	Nebula	6RF	38	4660	48.1	10.7	0	21	187
	Mean		16	4540	50.7	11.3	2	27	188
	LSD (p = 0.05)			700	0.6	0.4			
	CV (%)			9	1	2			

[1]/ 2RF - 2 row feed, 6RF - 6 row feed, 2RM - 2 row malt, 2RF/M - Variety being considered as a malt type.

[2]/ Percent of plant covered with barley stripe rust pustules.

Table 2. OSU Spring Barley Trial, Statewide Variety Testing Program, irrigated mineral soil site: grain yield of spring barley established at KES, Klamath Falls, OR, 1996-98.

Variety	Row	Use[1]	Yield 1998	Yield 1997	Yield 1996	2-year average yield	2-year average rank	3-year average yield	3-year average rank
			lb/A			lb/A		lb/A	
78Ab10274	2	F/M	4670	5280	4270	4980	5	4740	5
B 1202	2	M	4430	5080	5410	4760	8	4970	3
Baronesse	2	F	4730	5390	5150	5060	2	5090	1
Galena	2	M	4400	5230	5120	4820	7	4920	4
Gus	6	F	3470	3410	4210	3440	12	3700	8
Gustoe	6	F	3760	3160	4460	3460	11	3790	7
Idagold	2	F	4800	5370	4860	5090	1	5010	2
Steptoe	6	F	4710	4500	3930	4610	10	4380	6
Chinook	2	M	4860	5160		5010	3		
Gallatin	6	F	4720	5270		5000	4		
Orca	2	F	4940	4470		4710	9		
Nebula	6	F	4660	4990		4830	6		
Mean			4510	4780	4680	4650		4580	

[1]/ F denotes a feed barley variety, M denotes a malting line.

Table 3. Western Regional Spring Barley Nursery: agronomic data for spring barley lines established April 30 at KES, Klamath Falls, OR, 1998.

Entry	Variety	Row	Use[1]	Yield	Test wt	Thins 6/64	Thins 5.5/64	Thins pan	50% heading
				lb/A	lb/bu	%	%	%	Julian
1	Steptoe	6	F	3700	49.0	84.3	11.5	4.2	183
2	Klages	2	M	4940	55.0	91.0	6.0	3.0	189
3	Morex	6	M	3940	53.5	88.2	8.6	3.2	183
4	Stander	6	M	3960	54.5	93.2	5.5	1.3	184
5	Harrington	2	M	4840	54.0	84.3	10.0	5.7	190
6	ID 90241	2	M	4270	56.0	96.4	2.4	1.1	190
7	TR 128	2	--	4820	54.5	94.7	4.5	0.8	191
8	TR 133	2	--	4560	54.0	96.2	2.6	1.2	189
9	TR 139	2	--	5060	52.5	94.1	4.0	1.9	192
10	B 1202[2]	6	M	4550	55.5	97.2	2.1	0.7	190
11	ID 921368	6	M	3950	52.0	83.7	10.4	6.0	183
12	MT 910150	2	M	4360	55.5	95.3	3.6	1.1	187
13	Orca (OR2937045)	2	M	3970	55.5	97.9	1.5	0.6	185
14	WA 7642-92	2	M	4440	53.5	89.3	8.2	2.5	188
15	WPB BZ594-19	2	M	4820	55.5	96.4	2.5	1.1	188
16	BA 6B93-2978	6	M	3670	52.0	78.5	18.0	3.5	184
17	SK CDC Dolly	2	F	3890	52.0	92.4	5.8	1.7	190
18	SK CDC Fleet	2	F	3710	56.0	93.3	5.0	1.7	185
19	WA 9504-94	--	--	4520	56.0	94.4	3.8	1.9	194
20	WA 7114-93	--	--	4420	52.0	94.1	4.4	1.5	191
21	WA 10494-93	--	--	5150	56.0	96.2	2.7	1.0	186
22	OR 2967007	--	--	4270	52.0	78.3	14.6	7.0	182
23	BA 2B94-5328	2	M	3240	53.0	92.6	4.7	2.8	189
24	BA 2B94-5602	2	M	3330	53.5	93.9	3.8	2.3	192
25	BA 6B94-7378	6	M	3230	53.5	89.5	7.0	3.5	186
26	UT 4636	6	F	3290	51.5	84.5	11.0	4.6	184
27	UT 5645	6	F	3420	49.5	75.9	17.8	6.4	180
28	UT 5724	6	F	4730	49.0	75.3	15.5	9.1	180
29	MT 910189	2	M	4390	54.0	90.4	7.3	2.3	186
30	MT 920073	2	M	4340	54.5	96.3	3.1	0.6	187
	Mean			4190	53.5	90.3	6.9	2.8	187
	LSD (p = 0.05)			690					2
	CV (%)			12					1

1/ F denotes a feed barley variety, while M denotes a malting line.

2/ Entry 10: Substituted B 1202 for the missing UT 4603.

Table 4. Western Regional Spring Barley Nursery: grain yield of spring barley lines planted at KES, Klamath Falls, OR, 1996-98.

Variety	Row	Use[1]	Yield 1998	Yield 1997	Yield 1996	2-year average yield	2-year average rank	3-year average yield	3-year average rank
			lb/A	lb/A	lb/A	lb/A		lb/A	
Harrington	2	M	4840	5380	3320	5110	3	4510	4
Klages	2	M	4940	4670	3740	4810	7	4450	6
Morex	6	M	3940	5140	3220	4540	11	4100	9
Steptoe	6	F	3700	5000	3740	4350	13	4150	8
ID 90241	2	M	4270	5500	3720	4890	5	4500	5
SK TR 128	2	--	4820	5540	3260	5180	2	4540	3
SK TR 133	2	--	4560	4940	4210	4750	9	4570	2
SK TR 139	2	--	5060	4990	3810	5030	4	4620	1
Stander	6	M	3960	4370	4890	4170	16	4410	7
BA 6B93-2978	6	M	3670	4430		4050	17		
ID 921368	6	M	3950	4680		4320	14		
MT 910150	2	M	4360	5170		4770	8		
Orca	2	M	3970	4820		4400	12		
SK CDC Dolly	2	F	3890	5870		4880	6		
SK CDC Fleet	2	F	3710	4680		4200	15		
WA 7642-92	2	M	4440	5040		4740	10		
WPB BZ594-19	2	M	4820	5930		5380	1		
B 1202	6	F	4550						
BA 2B94-5328	2	M	3240						
BA 2B94-5602	2	M	3330						
BA 6B94-7378	6	M	3230						
MT 910189	2	M	4390						
MT 920073	2	M	4340						
OR 2967007	--	--	4270						
UT 4636	6	F	3290						
UT 5645	6	F	3420						
UT 5724	6	F	4730						
WA 10494-93	--	--	5150						
WA 7114-93	--	--	4420						
WA 9504-94	--	--	4520						
Mean			4190	5070	3770	4680		4430	
LSD (p = 0.05)			690	530	NS	270		370	
CV (%)			12	7	31	9		16	

[1]/ F denotes a feed barley variety, while M denotes a malting line.

Spring Wheat Variety Screening in the Klamath Basin, 1998

R.L. Dovel[1], R.S. Karow[2], and G. Chilcote[1]

Introduction

Spring wheat is grown on approximately 5,000 acres annually in Klamath County. Soft white (SW) and hard red (HR) selections predominate; however, interest has grown recently in the hard white (HW) class. In 1998, spring wheat variety trials were conducted at the KES in cooperation with Oregon State University and Western Regional plant breeding and evaluation programs. Cold-tolerant, short-season cultivars are needed in the Klamath Basin to accommodate a short growing-season with the possibility of frost throughout the season. Entries evaluated in these trials included SW, HW, and HR selections. Historically, there has been little disease or insect pressure on small grains in the Klamath Basin. However, the recent introduction of the Russian wheat aphid has altered this situation. Wheat stem maggot is endemic in the area and generally causes only slight damage at the KES. Under mild winter and warm spring conditions in 1992 and 1993, significant damage to cereal crops was experienced, with up to 50 percent of the tillers affected at KES and with serious crop losses in several commercial fields in the Lower Klamath Lake area.

Procedures

All small grain variety trials at the KES were on land planted in potatoes the previous year. Soils at the station include Poe, Fordney, and Hosley series, all of which have a fine loamy to sandy texture and are moderately deep and somewhat poorly drained. All plots were sprinkler irrigated.

All trials were arranged in a randomized complete block design with three or four replications. Plots were planted on April 30. Seed was planted at a depth of 2 inches. The seeding rate for the Oregon Statewide Variety trial was 30 seeds/ft^2. All other trials had a seeding rate of 100 lb/acre. All plots were fertilized with 20 lb N, 12 lb P_2O_5, and 9 lb S/acre at time of seeding. Additional fertilizer was broadcast before planting at 80 lb N, 48 lb P_2O_5, and 35 lb S/acre. Plots measured 5 × 20 feet, with 10 rows at 6-inch spacing. Bromoxynil and MCPA were applied at labeled rates to control broadleaf weeds. Plots were harvested in late September using a plot combine with a 5-foot wide header. Grain yield was recorded for all plots. Test weight was measured in only one replication.

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Results and Discussion

Statewide Spring Wheat Trial

ID 506 (SW) was the highest yielding entry in the 24-entry Statewide Spring Wheat Variety Trial (Table 1). Other high yielding SW entries included ID 505, Penewawa, WPB BZ 992-108, and Pomerelle. Pomerelle, formerly ID 448, was the third highest producing entry in 1997, the highest yielding entry in the 1996 trial, and the second highest producing entry in the 1995 trial. This newly released SW variety has produced grain of comparable test weight and lower protein than Penewawa and Centennial. It is a late maturing variety, which may cause problems in the short-season environment of the Klamath Basin. Centennial, which has been an outstanding SW variety in the past, produced less than the trial average in both 1997 and 1998 (Table 2). Penewawa has produced the highest average yield over a three-year period, followed closely by Pomerelle (Table 2).

The two top producing HR entries, WA 7802 and Jefferson, produced significantly higher yields than WPB 936R, the local industry standard. Yecora Rojo produced grain yields equivalent to WPB 936R. Jefferson is a new release out of Idaho. The highest producing HW entry, WA 7802, produced significantly higher yields than IDO 377S, a commercially available HW variety.

Western Regional Spring Wheat

Six entries produced over 5,000 lb of grain per acre. They included two soft white entries; WA 7850 and ID 526, two hard white entries; CA 1162 and CA 1128, and two hard red entries; CA 1158 and OR 4920002 (Table 3). There was no significant difference in yield among the five highest yielding entries.

From 1996 to 1998, IDO 488 was the highest yielding SW entry, CA 896 was the highest producing HW entry, and IDO 492 was the highest yielding HR entry. Over the same three-year period, Penewawa was the second highest producing entry, yielding an average of 620 lb/acre less than IDO 488.

The release of the high yielding lines discussed above would benefit grain producers in the Klamath Basin. Release of these promising lines depends on their performance in other areas and final approval by state and regional review boards.

OSU Soft White Spring Wheat

Two SW entries yielded over 5,000 lb of grain per acre, 4850001 and 4950006 (Table 5). The OSU selection 4850001 produced the highest yield in the trial. Soft white wheat varieties have been slow to mature in the cool fall conditions common in the Klamath Basin. The development of an earlier maturing, high yielding SW variety should help producers who choose to grow this commodity in the basin.

Table 1. Oregon Statewide Spring Wheat Trial: grain yield, test weight, and protein content of spring wheat lines established April 30 at KES, Klamath Falls, OR, 1998.

Entry	Variety	Type[1]	Yield	Test wt	Protein
			lb/A	lb/bu	%
1	Alpowa	SW	4370	62.4	12.1
2	Alpowa (no Gaucho)	SW	4930	62.4	12.2
3	IDO 377S	HW	5220	62.1	13.3
4	Jefferson (IDO 462)	HR	4960	62.0	14.1
5	IDO 505	SW	5680	62.4	11.4
6	IDO 506	SW	6150	62.7	11.7
7	IDO 523	HW	5500	61.1	12.5
8	IDO 533	HW	4670	59.9	12.6
9	OR 4870453	HW	4750	59.4	13.1
10	OR 4870255	HW	5300	63.1	14.1
11	OR 4920307	HW	4690	60.9	12.9
12	OR 3900362	HR	4210	61.0	14.3
13	OR 942845	SW	4640	61.9	12.9
14	Penawawa	SW	5470	61.5	12.3
15	Pomerelle	SW	5050	60.8	11.3
16	WA 7802	HR	5500	62.5	14.4
17	WA 7850	SW	4590	60.4	12.3
18	Wawawai	SW	4200	61.7	12.7
19	Whitebird	SW	5230	62.2	11.5
20	WPB 936	HR	3930	60.5	15.6
21	WPB BZ 987-331	HR	4280	59.5	14.8
22	WPB BZ 992-108	SW	5440	61.1	11.9
23	Yecora Rojo	HR	3960	61.9	15.0
24	Centennial	SW	3710	61.8	14.7
	Mean		4850	61.5	13.1
	LSD ($p = 0.05$)		930	1.4	0.8
	CV (%)		12	1	4

[1]/ HW denotes a hard white variety, HR denotes a hard red variety, SW denotes a softwhite variety.

Table 2. OSU Spring Wheat Trial, Statewide Variety Testing Program, grain yield of spring wheat established at KES, Klamath Falls, OR, 1996-98.

Variety	Type[1]	Yield 1998	Yield 1997	Yield 1996	2-year average yield	2-year average rank	3-year average yield	3-year average rank
		lb/A	lb/A	lb/A	lb/A		lb/A	
Alpowa	SW	4370	5970	5860	5170	6	5400	4
Alpowa (no Gaucho)	SW	4930	5040	6090	4990	8	5350	6
Centennial	SW	3710	4680	5520	4200	12	4640	10
IDO 377S	HW	5220	4860	6080	5040	7	5390	5
Jefferson (IDO 462)	HR	4960	4800	5300	4880	9	5020	7
Penawawa	SW	5470	7470	6040	6470	1	6330	1
Pomerelle	SW	5050	6120	6680	5590	2	5950	2
Wawawai	SW	4200	4920	4910	4560	10	4680	9
Whitebird	SW	5230	5650	6160	5440	4	5680	3
WPB 936	HR	3930	4850	5480	4390	11	4750	8
Yecora Rojo	HR	3960	4260	4080	4110	13	4100	11
OR 4870453	HW	4750	5860		5310	5		
WA 7802	HR	5500	5620		5560	3		
IDO 505	SW	5680						
IDO 506	SW	6150						
IDO 523	HW	5500						
IDO 533	HW	4670						
OR 3900362	HR	4210						
OR 4870255	HW	5300						
OR 4920307	HW	4690						
OR 942845	SW	4640						
WA 7850	SW	4590						
WPB BZ 987-331	HR	4280						
WPB BZ 992-108	SW	5440						
Mean		4850	5390	5660	5050		5210	

[1]/ HW denotes a hard white variety, HR denotes a hard red variety, SW denotes a softwhite variety.

Table 3. Western Regional Spring Wheat Nursery: agronomic and grain quality data for spring wheat lines established April 30 at KES, Klamath Falls, OR, 1998.

Entry	Variety	Type[1]	Yield	Test wt	Lodge	Height
			lb/A	lb/bu	%	inches
1	McKay	HR	4380	61.0	0	28
2	Federation	SW	3670	59.5	0	41
3	Penawawa	SW	4100	62.0	0	30
4	Klasic	HW	3800	62.5	0	24
5	Serra	HR	4490	61.5	0	28
6	OR 4920092	HW	4720	60.5	0	28
7	OR 3900362	HR	4720	62.0	0	26
8	SDM 50030	SW	4300	60.0	0	28
9	WA 7802	HR	4630	62.5	0	31
10	BR 2306	HR	4420	61.5	0	31
11	IDO 502	HR	4300	61.5	0	28
12	IDO 505	SW	4620	62.0	0	28
13	IDO 506	SW	4680	63.0	0	30
14	IDO 523	HW	4650	61.0	0	28
15	IDO 524	SW	4610	63.0	0	28
16	ML 107455	HW	4310	62.5	0	28
17	OR 4910028	HR	4930	61.5	0	30
18	OR 4920292	HW	4140	60.5	0	28
19	SDM 50031	HR	4150	63.0	0	28
20	SDM 50032	HR	4100	63.0	0	28
21	UT 2868	HR	4410	60.5	0	31
22	UT 3172	HR	4530	63.0	0	37
23	WA 7824	HR	4020	62.5	0	31
24	BR 3666	HR	4050	62.5	0	31
25	CA 1107	HW	3820	62.5	0	24
26	CA 1110	HW	4850	61.5	0	26
27	CA 1128	HW	5340	62.5	0	28
28	CA 1158	HR	5560	60.5	0	28
29	CA 1159	HR	4150	63.0	0	20
30	CA 1160	HR	4660	61.5	0	24

Table 3 (continued). Western Regional Spring Wheat Nursery: agronomic and grain quality data for spring wheat lines established April 30 at KES, Klamath Falls, OR, 1998.

Entry	Variety	Type[1]	Yield	Test wt	Lodge	Height
			lb/A	lb/bu	%	inches
31	CA 1161	HR	4190	58.5	0	28
32	CA 1162	HW	6160	64.5	0	31
33	CA 1163	HW	3300	62.0	0	18
34	IDO 508	HW	3300	62.5	0	30
35	IDO 525	SW	4620	63.0	0	31
36	IDO 526	SW	5220	63.0	0	31
37	IDO 527	SW	4780	59.5	0	31
38	IDO 528	HR	4440	62.0	0	26
39	IDO 533	HW	4840	63.0	0	31
40	ML 04-115,A	SW	3880	61.0	0	24
41	OR 4880372	HW	4020	63.0	0	28
42	OR 4920002	HR	5310	62.0	0	28
43	OR 942845	SW	4820	63.0	0	31
44	SDM 50102	HW	4920	62.0	0	28
45	WA 7850	SW	5280	62.0	0	28
	Mean		4490	61.9	0	29
	LSD (p = 0.05)		910			
	CV (%)		12			

[1]/ HW denotes a hard white variety, HR denotes a hard red variety, SW denotes a softwhite variety.

Table 4. Western Regional Spring Wheat Nursery: grain yield of spring wheat lines established at KES, Klamath Falls, OR, 1996-98.

Variety	Type[1]	Yield 1998	Yield 1997	Yield 1996	2-year average yield	2-year average rank	3-year average yield	3-year average rank
		lb/A			lb/A		lb/A	
CA 896	HW	3790	5210	3410	4500	8	4140	5
Federation	SW	3570	5000	3630	4290	10	4070	6
IDO 488	SW	5310	5840	4970	5580	1	5380	1
IDO 492	HR	4250	5220	4280	4740	6	4590	3
Klasic	HW	3480	3890	2770	3690	17	3380	9
McKay	HR	4020	3860	4060	3940	14	3980	7
OR 487401	HR	3820	4900	4050	4360	9	4260	4
Penawawa	SW	4600	5560	4110	5080	3	4760	2
Serra	HR	4130	3950	3430	4040	13	3840	8
CA 1032	HR	3870	3240		3560	18		
CA 1036	HR	3910	4200		4060	12		
CA 1037	HR	3700	3790		3740	16		
CA 1041	HR	3570	3910		3740	15		
OR 390362	HR	4610	5090		4850	5		
OR 492092	HW	3910	5520		4720	7		
SDM 50030	SW	4140	6090		5110	2		
UT 3007	HR	4270	4180		4230	11		
WA 7802	HR	4750	5250		5000	4		
Mean		4240	4680	3910	4400		4280	
LSD (p = 0.05)		930	740	600	780		480	
CV (%)		13	10	10	11		9	

[1]/ HW denotes a hard white variety, HR denotes a hard red variety, SW denotes a softwhite variety.

Table 5. OSU Soft White Spring Wheat Nursery: agronomic and grain quality data for spring wheat lines established April 30 at KES, Klamath Falls, OR, 1998.

Entry	Variety	Type	Yield	Test wt	Lodging	Height
			lb/A	lb/bu	%	inches
1	Dirkwin	SW	4270	58.5	0	31
2	4870532	SW	4180	61.0	0	30
3	4900021	SW	4060	63.0	0	30
4	4920012	SW	4640	61.0	0	30
5	4900007	SW	4440	63.0	0	28
6	4850001	SW	5490	63.5	0	30
7	4880013	SW	4840	62.5	0	31
8	4900085	SW	4110	63.0	0	28
9	942838	SW	4140	61.5	0	28
10	942845	SW	4300	62.0	0	30
11	942885	SW	4300	63.0	0	31
12	942889	SW	4490	62.0	0	31
13	4950027	SW	4540	62.0	0	33
14	WA 7831	SW	3770	60.5	0	30
15	ML 042409	SW	4140	61.5	0	30
16	OR 9640087	SW	3880	63.5	0	30
17	4950006	SW	5170	63.0	0	28
	Mean		4400	62.0	0	30
	LSD (p = 0.05)		500			
	CV (%)		8			

Oat Variety Screening in the Klamath Basin, 1998

R.L. Dovel and G. Chilcote[1]

Introduction

Oats have been a major crop in the Klamath Basin in the past. Acreage has increased in the past two years because of grower concerns about barley stripe rust. About 10,000 acres were grown in Klamath County. Klamath Experiment Station has cooperated in the Uniform Northwestern States Oat Nursery since the 1970's. Over the years, several outstanding varieties including Cayuse, Appaloosa, Border, and Ajay have been identified and adopted by local growers. Most of these varieties are still in use today; however, there are several experimental lines that appear to have higher yield potentials than the currently grown varieties. The Uniform Northwestern States Oat Nursery is planted at KES each year to identify promising new oat lines for release by public and private breeding programs.

Procedures

The Uniform Northwestern States Oat Nursery was established at KES on Fordney fine sandy loam soil that is moderately deep and somewhat poorly drained. The previous crop was potatoes. The crop was irrigated by a solid set sprinkler system. The trial was arranged in a randomized complete block design with four replications. Seed was planted on May 1 at a depth of 2 inches and a seeding rate of 100 lb/acre. All plots were fertilized with 20 lb N, 12 lb P_2O_5, and 9 lb S/acre at time of seeding. Additional fertilizer was broadcast before planting at 80 lb N, 48 lb P_2O_5, and 35 lb S/acre. Plots measured 5 x 20 feet with a row spacing of 6 inches. Bromoxynil and MCPA were applied at labeled rates to control broadleaf weeds. Plots were harvested in late September using a plot combine with a 5-foot wide header. Grain yield was recorded for all plots. Test weight was measured in only one replication.

Results and Discussion

The highest yielding line over a three-year period was 87Ab5125, which produced 4450 lb/acre. The second and third highest entries were 84Ab825 and AbSP 9-2 (Table 1). Although 87Ab5125 was high yielding, and did not lodge in 1998 or 1996, it had 16 percent lodging in 1997. Neither 84Ab825 nor AbSP 9-2 lodged in 1998 or 1996, but had 23 and 24 percent lodging, respectively, in 1997. AbSP 9-2 produced grain with test weights above 40 lb/bu in 1996 and 1997. These lines are a significant improvement over currently grown varieties and further testing is warranted.

Yields of the highest yielding commercially available varieties, Monida, Celsia, and Whitestone, were 4010, 3980, and 3940 lb/acre, respectively. Ajay and Cayuse, the two most commonly planted oat varieties in the Klamath Basin, averaged 3830 and 3440 lb/acre, respectively.

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Lodging has been a common problem with Cayuse and most other traditional oat varieties. Percent lodging in Cayuse was 0, 48, and 0 percent in 1998, 1997 and 1996, respectively (Tables 2, 3, and 4). In contrast, Ajay had only 1 percent lodging in 1997 and none in the other years. Rio Grande may be prone to lodging, averaging 3, 13, and 0 percent for 1998, 1997, and 1996, respectively. High yielding entries with low or no lodging over the last three years include 87Ab5125, Celsia, Ogle, and Ajay.

Table 1. Northwestern Uniform Oat Nursery: grain yield of oats established at KES, Klamath Falls, OR, 1996-98.

Variety	Yield 1998	Yield 1997	Yield 1996	2-year average yield	2-year average rank	3-year average yield	3-year average rank
	lb/A	lb/A	lb/A	lb/A		lb/A	
82Ab248	3840	3790	3390	3820	17	3670	15
84Ab825	3430	4320	4540	3880	16	4100	2
86Ab4582	2830	3980	3280	3410	23	3360	20
86Ab664	3020	4940	3730	3980	12	3900	8
87Ab4983	3550	4630	2620	4090	7	3600	17
87Ab5125	3460	5290	4600	4370	2	4450	1
89Ab4088	2760	5640	2700	4200	4	3700	14
90Ab1322	3760	3760	3870	3760	19	3800	11
91Ab502	3340	4820	3070	4080	8	3740	13
AbSP 9-2	2680	5430	4120	4060	9	4080	3
Ajay	4340	4420	2720	4380	1	3830	10
Cayuse	2570	4440	3300	3510	21	3440	18
Celsia	2340	5760	3850	4050	10	3980	5
Derby	1970	3540	2870	2760	27	2790	23
IA H61-3-3	2990	4490	4260	3740	20	3910	7
Monida	2660	5670	3700	4170	5	4010	4
ND 860416	2370	3230	3730	2800	26	3110	22
Ogle	2720	5700	3150	4210	3	3860	9
Otana	1960	4310	3860	3140	25	3380	19
Powell	3150	4620	3580	3890	14	3780	12
Prairie	2750	5010	2150	3880	15	3300	21
Rio Grande	3090	4710	3040	3900	13	3610	16
Whitestone	3060	4990	3760	4030	11	3940	6
91Ab406	3470	4070		3770	18		
AbSP 19-9	2870	5350		4110	6		
CDC Boyer	1970	5020		3490	22		
CDC Pacer	2270	4390		3330	24		
95Ab12743	3320						
ND 910569	2800						
ND 930122	3090						
Mean	2950	4680	3470	3810		3710	
LSD (p = 0.05)	660	NS	NS	870		730	
CV (%)	16	24	30	23		24	

Table 2. Northwestern Uniform Oat Nursery: grain yield, test weight, lodging, and plant height of oat lines established May 1 at KES, Klamath Falls, OR, 1998.

Entry	Variety	Yield	Test wt	Lodging	Height
		lb/A	lb/bu	%	inches
1	Cayuse	2570	27.5	0	39
2	Otana	1960	29.0	35	47
3	Monida	2660	28.0	20	35
4	Ogle	2720	27.0	3	37
5	Rio Grande (81Ab5792)	3090	29.0	3	33
6	82Ab248	3840	31.0	0	33
7	Ajay (82Ab1142)	4340	32.0	0	26
8	Powell (83Ab3250)	3150	29.5	1	35
9	86Ab664	3020	29.0	0	43
10	ND 860416	2370	32.0	23	43
11	87Ab5125	3460	28.5	0	43
12	84Ab825	3430	30.0	0	33
13	Derby	1970	28.0	10	51
14	87Ab4983	3550	32.5	0	37
15	IA H61-3-3	2990	32.0	0	39
16	Whitestone (ND870258)	3060	28.0	10	33
17	90Ab1322	3760	28.0	0	30
18	Celsia	2340	29.0	0	49
19	Prairie	2750	31.0	0	33
20	89Ab4088	2760	34.0	0	35
21	91Ab502	3340	32.5	10	41
22	86Ab4582	2830	29.5	15	45
23	AbSP 9-2	2680	27.5	25	45
24	AbSP 19-9	2870	31.5	13	33
25	91 Ab406	3470	29.0	0	31
26	CDC Boyer	1970	27.5	0	43
27	CDC Pacer	2270	29.0	15	37
28	95Ab12743	3320	30.0	25	41
29	ND 910569	2800	32.0	0	45
30	ND 930122	3090	33.5	0	35
	Mean	2950	29.9	7	38
	LSD (p = 0.05)	660	-	NS	
	CV (%)	16	-	278	

Table 3. Northwestern Uniform Oat Nursery: grain yield, test weight, lodging, plant height, and day of year of 50% heading in Julian days (number of days after January 1) of oat lines established May 8 at KES, Klamath Falls, OR, 1997.

Entry	Variety	Yield	Test wt	Lodging	Height	50% heading
		lb/A	lb/bu	%	inches	Julian
1	Cayuse	4440	36.0	48	34	194
2	Otana	4310	38.5	33	46	195
3	Monida	5670	37.5	54	42	195
4	Ogle	5700	38.0	8	41	189
5	Rio Grande (81Ab5792)	4710	38.0	13	38	191
6	82Ab248	3970	36.5	48	38	195
7	Ajay (82Ab1142)	4420	37.0	1	33	195
8	Powell (83Ab3250)	4620	35.0	41	39	195
9	86Ab664	4940	36.5	56	44	195
10	Newdak	4590	39.0	26	37	189
11	ND 860416	3230	39.5	40	37	194
12	87Ab5125	5290	39.5	16	37	195
13	84Ab825	4320	37.0	23	37	195
14	Derby	3540	40.0	18	45	195
15	87Ab4983	4630	39.0	4	34	189
16	89Ab6153	5460	41.0	0	33	189
17	IA H61-3-3	4490	36.0	23	39	194
18	Whitestone (ND 870258)	4990	41.0	35	39	194
19	89Ab1545	4230	39.0	3	38	185
20	90Ab1322	3760	35.0	11	31	195
21	Celsia	5760	39.0	8	40	195
22	Prairie	5010	38.0	4	37	191
23	89Ab4088	5640	40.5	18	38	192
24	91Ab502	4820	36.0	35	35	189
25	86Ab4582	3980	38.0	59	35	192
26	AbSP9-2	5430	41.5	24	39	193
27	AbSP 19-9	5350	37.0	30	38	194
28	91Ab406	4070	32.0	29	31	194
29	CDC Boyer	5020	40.0	46	43	193
30	CDC Pacer	4390	37.0	39	39	192
	Mean	4690	37.9	26	38	193
	LSD (p = 0.05)	NS	-	39	NS	2
	CV (%)	24	-	106	17	1

Table 4. Northwestern Uniform Oat Nursery: grain yield, test weight, lodging, plant height, and day of year of 50% heading in Julian days (number of days after January 1) of oat lines established May 8 at KES, Klamath Falls, OR, 1996.

Entry	Variety	Yield	Test wt	Lodging	Height	50% heading
		lb/A	lb/bu	%	inches	Julian
1	Park	2750	38.0	50	43	199
2	Cayuse	3300	36.0	0	39	197
3	Otana	3860	37.0	0	45	198
4	Monida	3700	38.0	0	45	199
5	Ogle	3150	35.0	0	35	196
6	Rio Grande (81Ab5792)	3040	39.0	0	39	196
7	82Ab248	3390	34.0	0	35	199
8	Ajay (82Ab1142)	2720	38.0	0	28	198
9	83Ab3250	3580	36.0	0	30	199
10	86Ab664	3730	38.0	0	35	198
11	Newdak	2580	30.0	0	37	195
12	ND 860416	3730	38.0	0	45	198
13	87Ab5125	4600	38.5	0	41	199
14	84Ab825	4540	35.0	0	37	199
15	88Ab3073+	2980	46.5	0	28	199
16	Derby	2870	38.0	5	49	199
17	86Ab1616+	3410	44.0	0	45	199
18	87Ab4983	2620	34.0	0	24	194
19	89Ab6153	3660	35.5	0	33	196
20	IA H61-3-3	4260	36.0	0	45	199
21	Whitestone (ND 870258)	3760	35.0	0	37	199
22	Paul (ND 862915)+	3220	45.0	0	35	199
23	89Ab1545	2360	34.0	0	31	193
24	90Ab1322	3870	41.5	0	28	199
25	Celsia	3850	39.0	0	30	199
26	Prairie	2150	33.0	0	33	197
27	89Ab4088	2700	30.5	0	35	198
28	91Ab502	3070	31.5	0	33	193
29	86Ab4582	3280	33.0	0	43	197
30	AbSP 9-2	4120	42.0	0	39	197
	Mean	3360	37.0	2	37	198
	LSD (p = 0.05)	NS				1
	CV (%)	30				0

Barley Stripe Rust Control in the Klamath Basin, 1998

Randy Dovel[1], Steve Orloff[2], Greg Chilcote[1], Don Kirby[2]

Introduction

Barley stripe rust (BSR) is a newly introduced barley pest in the Klamath Basin. BSR was introduced from Europe into South America in 1975. By 1990, the disease was established in central Mexico and in 1991 the disease was reported in Texas. BSR spread to Colorado in 1992 and Arizona and Idaho in 1993. Several barley plants with symptoms typical of the disease were found in the Lower Lake leases in 1994, but laboratory confirmation of the presence of the disease was not possible. Economically significant occurrences of the disease were seen in the Klamath Basin for the first time in 1995. Significant losses from BSR infection occurred throughout the Klamath Basin in 1996 and 1997.

The impact of BSR on barley yield can be devastating with up to 85 percent yield reduction reported from Bolivia and Mexico. In general, yield reduction in the United States has been less than in Latin America. However, the cool, moist spring conditions of the Pacific Northwest could provide an ideal environment for BSR, and appropriate precautions should be taken.

Breeding programs at OSU, UC Davis, WSU, and USDA research centers in Idaho are all working to develop resistant spring and winter varieties. Seed of resistant winter varieties is now available. Seed of resistant spring varieties will be available in quantity in 2000. Until seed of resistant varieties is readily available, producers must rely on chemical control of the disease.

Tilt is currently the only fungicide registered for foliar application to control BSR on barley in Oregon. Tilt cannot be applied after flag leaf emergence. Folicur is a systemic fungicide that should soon be registered in Oregon for BSR control in barley. A section 18 emergency exemption was available in Oregon for Folicur in 1996, 1997, and 1998 is anticipated in 1999. Folicur may be applied as late as 50 percent head emergence. Quadris is another new fungicide that may be available for BSR control in the near future.

Procedures

The effectiveness of three foliar fungicides was evaluated at a mineral soil site (KES) and an irrigated organic soil site in Siskiyou Co., California. Foliar fungicides were applied to plots at early boot, early heading, and 50 percent head emergence. BSR infection at time of fungicide application in 1998 was less than 1 percent at the organic soil site and over 5 percent at KES.

Plots measured 15 x 40 feet, with a row spacing of 6 inches. All sites were sprinkler irrigated. All trials were

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arranged in a randomized complete block design with four replications. Seed was planted one inch deep at a seeding rate of 100 lb/acre. All plots received 50 lb N, 30 lb P_2O_5, and 22 lb S/acre by broadcast application before planting and 30 lb N, 18 lb P_2O_5, and 13 lb S/acre banded at planting. At KES, bromoxynil and MCPA were applied at labeled rates to control broadleaf weeds. Weed control at the organic soil site was achieved with a mixture of 2,4-D and Banvel. Grain was harvested in late September using a plot combine with a 5-foot wide header. Grain yield, test weight, percent plumps, and percent thins were recorded for all plots.

Results

All fungicide treatments reduced BSR infection compared to the untreated control at all application dates and both locations (Tables 1 and 2). At KES, Folicur and Quadris provided better BSR control than Tilt; however there were no yield differences among treatments. At the organic soil site, Quadris improved BSR control over Tilt and Folicur, but again there were no differences in yield. At KES, fungicide applications at boot and early heading were more effective than at 50% heading in terms of BSR control. Differences between timing treatments, at the organic site were not significant.

There was no treatment effect on grain yield at the organic soil site because of lodging and low BSR incidence. At the KES, lodging also reduced yields, but treatment effects on grain yield were significant. Yield response to fungicide treatment was greatest when applied at the boot stage at KES. Decreasing yield response was recorded as fungicide application was delayed. No yield increase was detected when treatments were applied at 50% heading.

These results were in contrast to the preceeding two years when application of foliar fungicide was economically beneficial in three of four trials. Foliar fungicide application at the organic soil site resulted in an average increase in production of 1430 and 1160 lb/acre in 1996 and 1997, respectively. Foliar fungicide application at KES resulted in an average increase in production of 250 and 850 lb/acre in 1996 and 1997, respectively. Lower fungicide treatment yield response in 1998 was likely caused by reduction of yield potential associated with lodging.

Table 1. Foliar fungicide effects on barley stripe rust infestation (BSR) and grain yield and quality of Steptoe spring barley planted at Klamath Experiment Station (KES) in Klamath County, Oregon in 1998.

Treatment		Grain	Test	% Above screen			BSR
stage	fungicide	yield	wt	6/64	5.5/64	Pan	infection
		lb/A	lb/bu		%		%
Boot	Control	4250	49.8	81.0	9.5	9.4	84
Boot	Tilt	5050	51.6	90.6	5.6	3.8	36
Boot	Folicur	4880	50.9	84.5	8.3	7.2	14
Boot	Quadris	5100	51.9	90.1	5.7	4.2	16
Early heading	Control	4230	50.4	80.0	10.4	9.6	87
Early heading	Tilt	4760	51.8	89.4	6.3	4.3	26
Early heading	Folicur	4380	50.3	82.9	8.3	8.8	19
Early heading	Quadris	4600	50.8	84.4	7.5	8.1	22
50% heading	Control	3950	48.6	76.4	11.5	12.1	88
50% heading	Tilt	4540	50.4	84.2	9.1	6.7	48
50% heading	Folicur	4150	49.8	79.7	10.3	10.0	41
50% heading	Quadris	4080	49.8	80.2	10.9	8.8	40
Mean		4470	50.5	84.0	8.5	7.5	43
Treatment main effects:							
Stage							
Boot		4820	51.1	86.6	7.3	6.2	38
Early heading		4490	50.8	84.2	8.1	7.7	39
50% heading		4180	49.7	80.1	10.5	9.4	54
LSD (p=0.05)		230	0.9	3.6	1.6	2.2	3
CV (%)		34	2	6	25	39	11
Fungicide							
Control		4140	49.6	79.1	10.5	10.4	86
Tilt		4780	51.2	88.1	7.0	4.9	37
Folicur		4470	50.3	82.4	9.0	8.7	25
Quadris		4590	50.8	84.9	8.0	7.0	26
LSD (p = 0.05)		320	1.0	6.3	1.7	NS	6
CV (%)		23	2	8	22	65	14

Table 2. Foliar fungicide effects on barley stripe rust infestation (BSR) and grain yield and quality of Steptoe spring barley planted in Siskiyou County, California in 1998.

Treatment stage	Treatment fungicide	Grain yield	Test wt	% Above screen 6/64	% Above screen 5.5/64	% Above screen Pan	BSR infection
		lb/A	lb/bu	%			%
Boot	Control	5150	47.6	82.1	11.8	6.1	35
Boot	Tilt	4750	47.8	83.3	11.1	5.7	18
Boot	Folicur	5050	46.6	79.3	14.0	6.8	10
Boot	Quadris	4960	49.4	89.3	7.3	3.4	8
Early heading	Control	4480	46.4	76.3	15.4	8.3	34
Early heading	Tilt	4340	48.7	85.0	9.7	5.2	7
Early heading	Folicur	4770	47.8	82.0	12.4	5.7	10
Early heading	Quadris	4920	47.9	87.1	8.5	4.4	2
50% heading	Control	4710	47.3	79.6	13.1	7.3	40
50% heading	Tilt	4710	47.7	81.5	11.9	6.6	13
50% heading	Folicur	4550	47.6	83.1	11.1	5.8	9
50% heading	Quadris	4940	48.3	87.6	8.3	4.0	5
Mean		4780	47.8	83.0	11.2	5.8	16
Treatment main effects:							
Stage							
Boot		4980	47.9	83.5	11.1	5.5	18
Early heading		4630	47.7	82.6	11.5	5.9	13
50% heading		4730	47.7	83.0	11.1	5.9	17
LSD (p=0.05)		NS	NS	NS	NS	NS	NS
CV (%)		11	4	6	25	45	26
Fungicide							
Control		4780	47.1	79.3	13.4	7.2	36
Tilt		4600	48.1	83.3	10.9	5.8	13
Folicur		4790	47.3	81.5	12.5	6.1	10
Quadris		4940	48.5	88.0	8.0	3.9	5
LSD (p = 0.05)		NS	NS	3.6	2.2	1.7	5
CV (%)		9	3	5	23	36	38

Alfalfa Variety Trial 1996-1998

R.L. Dovel and J. Rainey[1]

Introduction

Alfalfa is a major forage commodity in the Klamath Basin. It is grown on over 40,000 acres in Klamath County alone. Major markets for Klamath Basin alfalfa are dairies, cattle ranches, and horse farms in Oregon and California. Premium quality hay suitable for the dairy hay market requires timely cutting, good weed control, and an adequate stand. Little difference in forage quality has been seen between alfalfa varieties in the past. Breeding programs are striving to improve alfalfa quality. Varieties reportedly superior in quality are beginning to be marketed; however, management still appears to have more effect on forage quality than varietal differences.

Few pests attack alfalfa in the Klamath Basin. The main diseases present are bacterial wilt and phytophthora root rot. Verticillium wilt has not been found in the Klamath Basin, but it occurs in many surrounding areas. The main insect pest is the alfalfa weevil. Some breeding programs are beginning to select for resistance to this pest. Pest resistances are important variety selection criteria.

Winter hardiness is important in selecting a variety for the Klamath Basin. Winter hardiness has been closely linked with fall dormancy ratings; however, less dormant varieties have experienced reasonable stand longevity in recent years, perhaps caused by relatively mild winters. Local variety trials are being used to develop empirical winter hardiness and stand-persistance measurements to supplement fall dormancy ratings as a measure of variety hardiness.

Forage yield is a function of a complex set of interactions between the alfalfa plant and its environment. Variety trials conducted at the KES provide alfalfa producers locally developed data on the yield potential and persistence of new alfalfa varieties. An alfalfa variety trial established at KES in 1996 is the subject of this report.

Procedures

A trial including 28 released and experimental alfalfa varieties was established in August, 1996. Varieties were arranged in a randomized complete block design with four replications. Soil samples from the field were analyzed and

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the appropriate fertilizer applied before planting. Seed was drilled to a depth of 1/4 inch at a rate of 20 lb/acre using a modified Kincaid drill. Plots were 5 x 30 feet with 5-foot borders and alleyways. The crop was sprinkler irrigated with a solid-set system.

Plants were allowed to grow through the first growing season without cutting. Alfalfa was harvested in subsequent years when plants reached early bud stage. The crop was harvested using a flail harvester with a three-foot wide head. All yields are reported on a dry weight basis. Three cuttings were also taken in 1997 and in 1998.

Results and Discussion

There was no significant difference in yield among varieties in the first and second cuttings in 1997 and in any cutting in 1998 (Tables 1 and 2). There were significant differences in the 1997 third cutting, but not in total forage yield in either year. Failure to distinguish between varieties was not a result of high variability. Coefficients of variation in 1997 were 10, 11, 8, and 6 for first, second, and third cuttings, and total yield, respectively. In the first cutting, forage production ranged from 2.90 ton/acre for Excalibur II to 2.33 ton/acre for 5246. This is a difference from lowest to highest of just over one-half ton/acre. A similar range in yields was seen in the second and third harvests as well, 0.42 and 0.54 ton/acre, respectively. In 1998, the range in yield from highest to lowest was 1.4, 0.7, 0.4, and 1.4 ton/acre for first, second, third, and total yield, respectively. Differences in forage quality were not detected in the first two harvest years despite low variation as indicated by coefficients of variation (CV's) (Tables 3 and 4). Across year analysis yielded no significant differences in either yield or quality (Table 5).

The selection of an appropriate alfalfa variety should be based on other factors in addition to yield and quality. Disease and pest resistance and winter hardiness are two very important factors. Varieties selected for the Klamath Basin should be resistant to bacterial wilt, phytophthora root rot, verticilium wilt, and in some areas, stem nematode. Resistance to root-knot nematode may also be a factor when in rotation with potatoes. In the past, fall dormancy ratings of 2 to 3 have been recommended for the Klamath Basin; however, recent varieties in groups 4 and even 5 have persisted over a four-year period. Fall dormancy ratings and pest resistance ratings of varieties included in this trial are provided in Table 6.

The collection of only two years of data is inadequate to provide an estimate of the relative yield potential of the varieties in this trial. An additional year or more of data are needed to adequately assess yield potential and to evaluate stand survival in this environment.

Table 1. 1997 forage yield of 28 alfalfa varieties planted at the KES, Klamath Falls, OR, 1996.

Entry	Variety	Company	Cut 1	Cut 2	Cut 3	Total	Rank
			ton/A				
1	Rushmore	Novartis Seeds	2.64	1.47	1.99	6.10	20
2	Aspen	Eureka Seeds	2.74	1.51	1.81	6.06	23
3	Innovator +Z	America's Alfalfa	2.70	1.57	2.05	6.32	13
4	Affinity + Z	America's Alfalfa	2.52	1.60	1.97	6.09	21
5	ABI 9352	America's Alfalfa	2.44	1.58	1.96	5.98	24
6	LM-331	Loshe Mill	2.72	1.44	1.96	6.12	19
7	H 154	Loshe Mill	2.54	1.65	1.71	5.90	27
8	LM 459	Loshe Mill	2.41	1.79	1.94	6.14	18
9	Accord	Union Seed/Chemgro	2.77	1.70	1.86	6.33	10
10	DK127	Dekalb Genetics Corp.	2.75	1.58	1.92	6.25	15
11	5396	Pioneer Hi-Breed Int	2.72	1.68	1.98	6.38	5
12	5246	Pioneer Hi-Breed Int	2.33	1.42	1.95	5.70	28
13	Extend	Grasslands West	2.85	1.44	2.03	6.32	14
14	Charger	Grasslands West	2.74	1.60	1.88	6.22	16
15	Webfoot MPR	Great Lakes Hybrids	2.88	1.47	2.03	6.38	7
16	Excalibur II	Allied Seed	2.90	1.69	1.98	6.57	1
17	Magnum III	Dairyland	2.77	1.61	1.95	6.33	11
18	Oneida VR	Public	2.72	1.72	2.01	6.45	2
19	Vernal	Public	2.8	1.44	1.94	6.18	17
20	Vernema	Public	2.58	1.55	1.83	5.96	25
21	W45	Public	2.48	1.44	1.99	5.91	26
22	HayGrazer	Great Plains Research	2.69	1.54	2.10	6.33	12
23	WL 252 HQ	WL Research Inc.	2.79	1.59	2.06	6.44	3
24	Blazer	Croplan Genetics	2.67	1.56	2.18	6.41	4
25	Blazer XL	Croplan Genetics	2.55	1.53	1.99	6.07	22
26	Baralfa 54	Barenbrug, USA	2.61	1.84	1.90	6.35	9
27	Baralfa 32 IQ	Barenbrug, USA	2.72	1.63	2.02	6.37	8
28	Ranger	Public	2.62	1.51	2.25	6.38	6
	Mean		2.67	1.58	1.97	6.22	
	CV (%)		10	11	8	6	
	LSD (p = 0.05)		NS	NS	0.22	NS	

Table 2. 1998 forage yield of 28 alfalfa varieties planted at KES, Klamath Falls, OR, 1996.

Entry	Variety	Company	Cut 1	Cut 2	Cut 3	Total	Rank
			ton/A				
1	Rushmore	Novartis Seeds	3.29	2.21	1.90	7.39	13
2	Aspen	Eureka Seeds	2.80	2.70	1.70	7.20	19
3	Innovator +Z	America's Alfalfa	3.48	2.83	1.50	7.81	3
4	Affinity + Z	America's Alfalfa	3.26	2.67	1.63	7.55	8
5	ABI 9352	America's Alfalfa	3.05	2.40	1.57	7.02	27
6	LM-331	Loshe Mill	3.30	2.63	1.58	7.51	9
7	H 154	Loshe Mill	4.10	2.51	1.69	8.30	1
8	LM 459	Loshe Mill	3.26	2.30	1.55	7.11	23
9	Accord	Union Seed/Chemgro	3.69	2.27	1.68	7.65	7
10	DK127	Dekalb Genetics Corp.	3.55	2.41	1.79	7.75	4
11	5396	Pioneer Hi-Breed Int	3.81	2.22	1.69	7.73	5
12	5246	Pioneer Hi-Breed Int	3.19	2.47	1.61	7.26	18
13	Extend	Grasslands West	3.15	2.72	1.80	7.67	6
14	Charger	Grasslands West	3.27	2.24	1.55	7.07	24
15	Webfoot MPR	Great Lakes Hybrids	3.36	2.50	1.62	7.48	11
16	Excalibur II	Allied Seed	3.21	2.46	1.70	7.37	14
17	Magnum III	Dairyland	3.23	2.28	1.55	7.06	25
18	Oneida VR	Public	2.91	2.47	1.48	6.86	28
19	Vernal	Public	3.59	2.62	1.71	7.92	2
20	Vernema	Public	3.20	2.49	1.49	7.18	20
21	W45	Public	3.19	2.16	1.69	7.04	26
22	HayGrazer	Great Plains Research	2.99	2.73	1.54	7.26	17
23	WL 252 HQ	WL Research Inc.	3.34	2.27	1.72	7.33	15
24	Blazer	Croplan Genetics	3.41	2.54	1.49	7.45	12
25	Blazer XL	Croplan Genetics	3.19	2.41	1.67	7.27	16
26	Baralfa 54	Barenbrug, USA	2.70	2.64	1.83	7.17	21
27	Baralfa 32 IQ	Barenbrug, USA	3.58	2.07	1.49	7.14	22
28	Ranger	Public	3.24	2.54	1.72	7.50	10
	Mean		3.30	2.45	1.64	7.39	
	CV (%)		17	13	13	8	
	LSD (p = 0.05)		NS	NS	NS	NS	

Table 3. 1997 alfalfa forage quality as measured by crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), and relative feed value (RFV), of 28 varieties planted at KES, Klamath Falls, OR, 1996.

	Variety	Company	CP	ADF	NDF	TDN	RFV
			%				
1	Rushmore	Novartis Seeds	20.8	36.7	45.5	54.2	123.5
2	Aspen	Eureka Seeds	23.0	34.0	43.0	57.3	135.4
3	Innovator +Z	America's Alfalfa	22.6	33.9	43.4	57.4	135.1
4	Affinity + Z	America's Alfalfa	22.8	32.9	44.0	59.0	134.3
5	ABI 9352	America's Alfalfa	23.3	32.8	43.0	58.7	137.4
6	LM-331	Loshe Mill	21.9	35.4	45.0	55.7	127.2
7	H 154	Loshe Mill	21.4	35.3	45.8	55.8	125.2
8	LM 459	Loshe Mill	21.0	36.0	45.8	55.0	124.4
9	Accord	Union Seed/Chemgro	22.8	33.6	42.4	57.8	138.9
10	DK127	Dekalb Genetics Corp.	24.1	32.3	41.2	59.2	144.6
11	5396	Pioneer Hi-Breed Int	22.5	33.5	43.2	57.8	135.6
12	5246	Pioneer Hi-Breed Int	22.5	33.6	43.8	57.7	133.4
13	Extend	Grasslands West	21.9	35.1	44.8	56.1	128.2
14	Charger	Grasslands West	21.3	35.8	44.9	55.2	126.6
15	Webfoot MPR	Great Lakes Hybrids	21.7	34.0	44.4	57.3	131.3
16	Excalibur II	Allied Seed	22.5	34.2	43.6	57.0	133.3
17	Magnum III	Dairyland	22.6	33.6	42.7	57.8	137.2
18	Oneida VR	Public	22.5	33.3	42.4	58.0	138.3
19	Vernal	Public	22.7	33.6	42.6	57.7	137.2
20	Vernema	Public	21.3	35.4	44.4	55.7	128.9
21	W45	Public	21.2	35.7	45.4	55.3	125.7
22	HayGrazer	Great Plains Research	22.9	33.7	43.0	57.6	136.5
23	WL 252 HQ	WL Research Inc.	23.4	32.6	42.4	58.9	139.8
24	Blazer	Croplan Genetics	22.0	34.4	44.6	56.8	130.0
25	Blazer XL	Croplan Genetics	23.6	32.7	42.3	58.8	139.6
26	Baralfa 54	Barenbrug, USA	23.1	33.1	42.1	58.2	140.3
27	Baralfa 32 IQ	Barenbrug, USA	21.9	34.7	45.0	56.4	128.9
28	Ranger	Public	21.6	35.1	44.1	56.0	130.7
	Mean		22.3	34.2	43.7	57.1	133.0
	CV (%)		8	7	6	5	9
	LSD (p = 0.05)		NS	NS	NS	NS	NS

Table 4. 1998 alfalfa forage quality as measured by crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), and relative feed value (RFV), of 28 varieties planted at KES, Klamath Falls, OR, 1996.

	Variety	Company	CP	ADF	NDF	TDN	RFV
			%				
1	Rushmore	Novartis Seeds	20.7	34.6	44.4	56.6	130.0
2	Aspen	Eureka Seeds	20.2	35.8	46.0	55.2	123.9
3	Innovator +Z	America's Alfalfa	19.4	36.4	46.2	54.5	121.9
4	Affinity + Z	America's Alfalfa	20.4	35.5	45.4	55.5	125.6
5	ABI 9352	America's Alfalfa	21.0	33.6	44.0	57.7	133.1
6	LM-331	Loshe Mill	20.6	34.9	46.0	56.3	125.2
7	H 154	Loshe Mill	21.8	33.3	43.8	58.0	133.8
8	LM 459	Loshe Mill	20.6	34.7	44.8	56.4	129.0
9	Accord	Union Seed/Chemgro	20.6	35.2	44.1	55.9	130.0
10	DK127	Dekalb Genetics Corp.	19.8	36.3	45.8	54.7	124.5
11	5396	Pioneer Hi-Breed Int	20.4	34.9	44.7	56.2	128.8
12	5246	Pioneer Hi-Breed Int	20.6	35.9	45.7	55.1	124.9
13	Extend	Grasslands West	19.9	35.7	46.0	55.3	123.8
14	Charger	Grasslands West	21.1	34.6	44.4	56.6	130.4
15	Webfoot MPR	Great Lakes Hybrids	21.4	33.8	43.9	57.5	132.8
16	Excalibur II	Allied Seed	19.6	36.0	45.7	54.9	124.7
17	Magnum III	Dairyland	20.5	35.2	45.7	55.9	125.5
18	Oneida VR	Public	20.6	35.9	45.7	55.1	124.5
19	Vernal	Public	19.8	37.8	48.7	52.9	113.7
20	Vernema	Public	19.0	37.1	46.6	53.7	120.6
21	W45	Public	21.5	33.5	44.2	57.8	133.5
22	HayGrazer	Great Plains Research	21.0	35.5	44.5	55.5	128.5
23	WL 252 HQ	WL Research Inc.	21.2	34.2	44.2	57.0	131.6
24	Blazer	Croplan Genetics	19.3	37.0	47.1	53.8	119.1
25	Blazer XL	Croplan Genetics	20.6	35.6	45.8	55.4	124.7
26	Baralfa 54	Barenbrug, USA	19.2	37.1	47.1	53.7	119.7
27	Baralfa 32 IQ	Barenbrug, USA	21.3	33.6	43.4	57.7	135.2
28	Ranger	Public	20.2	35.6	45.9	55.5	124.2
	Mean		20.4	35.3	45.3	55.7	126.5
	CV (%)		3	7	6	5	9
	LSD (p = 0.05)		NS	NS	NS	NS	NS

Table 5. Summary of 1997 and 1998 alfalfa forage yield and quality as measured by crude protein (CP) and acid detergent fiber (ADF), of 28 varieties planted at KES, Klamath Falls, OR, 1996.

		Total Yield			CP			ADF		
	Variety	1997	1998	2-yr avg	1997	1998	2-yr avg	1997	1998	2-yr avg
		ton/A			%			%		
1	Rushmore	6.10	7.39	6.75	20.8	20.7	20.7	36.7	34.6	35.6
2	Aspen	6.06	7.20	6.63	23.0	20.2	21.6	34.0	35.8	34.9
3	Innovator +Z	6.32	7.81	7.06	22.6	19.4	21.0	33.9	36.4	35.1
4	Affinity + Z	6.09	7.55	6.82	22.8	20.4	21.6	32.9	35.5	34.2
5	ABI 9352	5.98	7.02	6.50	23.3	21.0	22.1	32.8	33.6	33.2
6	LM-331	6.12	7.51	6.82	21.9	20.6	21.2	35.4	34.9	35.1
7	H 154	5.90	8.30	7.10	21.4	21.8	21.6	35.3	33.3	34.3
8	LM 459	6.14	7.11	6.62	21.0	20.6	20.8	36.0	34.7	35.4
9	Accord	6.33	7.65	6.99	22.8	20.6	21.7	33.6	35.2	34.4
10	DK127	6.25	7.75	7.00	24.1	19.8	22.0	32.3	36.3	34.3
11	5396	6.38	7.73	7.05	22.5	20.4	21.5	33.5	34.9	34.2
12	5246	5.70	7.26	6.48	22.5	20.6	21.6	33.6	35.9	34.7
13	Extend	6.32	7.67	6.99	21.9	19.9	20.9	35.1	35.7	35.4
14	Charger	6.22	7.07	6.64	21.3	21.1	21.2	35.8	34.6	35.2
15	Webfoot MPR	6.38	7.48	6.93	21.7	21.4	21.5	34.0	33.8	33.9
16	Excalibur II	6.57	7.37	6.97	22.5	19.6	21.0	34.2	36.0	35.1
17	Magnum III	6.33	7.06	6.69	22.6	20.5	21.6	33.6	35.2	34.4
18	Oneida VR	6.45	6.86	6.66	22.5	20.6	21.6	33.3	35.9	34.6
19	Vernal	6.18	7.92	7.05	22.7	19.8	21.3	33.6	37.8	35.7
20	Vernema	5.96	7.18	6.57	21.3	19.0	20.2	35.4	37.1	36.3
21	W45	5.91	7.04	6.48	21.2	21.5	21.3	35.7	33.5	34.6
22	HayGrazer	6.33	7.26	6.80	22.9	21.0	22.0	33.7	35.5	34.6
23	WL 252 HQ	6.44	7.33	6.89	23.4	21.2	22.3	32.6	34.2	33.4
24	Blazer	6.41	7.45	6.93	22.0	19.3	20.6	34.4	37.0	35.7
25	Blazer XL	6.07	7.27	6.67	23.6	20.6	22.1	32.7	35.6	34.2
26	Baralfa 54	6.35	7.17	6.76	23.1	19.2	21.2	33.1	37.1	35.1
27	Baralfa 32 IQ	6.37	7.14	6.75	21.9	21.3	21.6	34.7	33.6	34.1
28	Ranger	6.38	7.50	6.94	21.6	20.2	20.9	35.1	35.6	35.3
	Mean	6.22	7.39	6.81	22.3	20.4	21.4	34.2	35.3	34.8
	CV (%)	6	8	8	8	3	8	7	7	7
	LSD (p = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 6. Alfalfa variety fall dormancy rating (FD); and resistance to bacterial wilt (BW), verticillium wilt (VW), fusarium wilt (FW), anthracnose (AN), phytophthera root rot (PRR), spotted alfalfa aphid (SAA), pea aphid (PA), blue alfalfa aphid (BAA), stem nematode (SN), aphanomyces root rot race 1 (APH), Southern root knot nematode (SRKN), and Northern root knot nematode (NRKN). Data taken from Certified Seed Council's "Fall Dormancy and Pest Resistance Ratings for Alfalfa Varieties", 1997/98 Edition unless otherwise stated.

Variety	FD	BW	VW	FW	AN	PRR	SAA	PA	BAA	SN	APH	SRKN	NRKN
Rushmore	4	HR	R	HR	HR	HR	HR	HR		MR	HR		
Aspen	4	HR	R	HR	HR	HR	HR	HR		R	R		R
Innovator +Z	3	HR	HR	HR	HR	HR	MR	R	S	R	R		
Affinity + Z	4	HR	HR	HR	HR	HR		R		R	R		
ABI 9352 [1]	5	R	HR	HR	HR	R	R	MR	HR	R			HR
LM-331 [1]	4	R	R	HR	R	R	MR	MR		HR	MR		
H-154	5			HR		R	HR	HR	R	R		R	
LM 459	5	MR	MR	HR	R	R	HR	HR	R	R			R
Accord	4	HR	R	HR	HR	HR		HR		MR	R		MR
DK127	3	HR	R	R	HR	HR	HR	HR		R	HR		R
5396 [1]	3	HR	HR	R	R	R	R	R		MR	MR		MR
5246	3	R	R	R	HR	R	R	R		HR	R		
Extend	3	HR	R	HR	HR	HR				R	R		
Charger [1]	3	HR	R	HR	HR	HR				R	R		
Webfoot MPR	4	HR	HR	HR	HR	HR		R			R		
Excalibur II [1]		HR	R	HR	HR	HR	HR	R		MR	R		MR
Magnum III	4	R	MR	R	MR	R	MR	R	MR	MR	LR		
Oneida VR	3	R	HR	HR	MR	MR							
Vernal	2	R		MR									MR
Vernema	4	MR	MR		LR	LR	MR			HR			
W45 [1]	5	MR	LR	HR			R			R			
HayGrazer	4	HR	R	HR	R	R	R	R	R		MR	MR	
WL 252 HQ	2	HR	HR	HR	HR	HR	MR	R		MR	R		
Blazer	3	HR	LR	R	LR	MR		HR		HR			
Blazer XL	3	R	R	HR	HR	HR	HR	R		R	R		
Baralfa 54 [1]	5	R	R	HR	HR	HR	HR	HR	MR	R			
Baralfa 32 IQ [1]	3	HR	R	HR	HR	HR	HR	R	R	R	HR		
Ranger [1]	3	LR		MR									

[1]/ Data based on company or breeder information.

Pasture and Hay Grass Variety Trial, 1998

R.L. Dovel and J. Rainey[1]

Introduction

Several grass hay variety trials were established at Klamath Experiment Station in 1988. More recently developed varieties require evaluation in the Klamath Basin. In addition, there is a need to test pasture grasses under a management system that more accurately reflects controlled grazing rather than a three-cutting hay schedule. In 1995, a trial was established to evaluate forage production and stand persistence of pasture grasses in the Klamath Basin under both haying and simulated grazing management. Entries included released and soon-to-be-released varieties of tall fescue, orchardgrass, perennial ryegrass, and *Bromus* species.

Procedures

The trial was planted in the fall of 1995 at KES. Plots were arranged in a randomized split-plot design with clipping management as the main plot, and variety as the split-plot, with 3 replications. Seed was planted at 0.25-inch depth in 6-inch rows using a cone seeder. Recommended seeding rates were used for each species. Plots were 5 × 20 feet with 5-foot wide alleyways.

Before seeding, fertilizer was applied and incorporated as indicated by soil tests. Seventy-five lb N/acre was applied at planting. Following establishment, 50 lb N/acre was applied in mid-March, mid-June, and mid-July. Plots were irrigated weekly with solid-set sprinklers based on evapotranspiration determined from a weather station on site.

Plots were allowed to grow unclipped in the establishment year. Plots managed for hay production were cut when 50 percent of the entries were heading. Cutting height in these plots was 2 inches. Plots managed as simulated grazing were cut when 50 percent of the entries reached 10 inches or more in height. Simulated grazing plots were cut to a 4-inch height. forages were clipped with a Carter flail plot-harvester. Measurements were taken for three full production years. Winter survival will be determined for three winter periods.

All yields are reported on a dry weight basis. Forage quality, as determined by crude protein (CP), acid detergent fiber (ADF), neutral detergent fiber (NDF), total digestible nutrients (TDN), and relative feed value (RFV), was evaluated from samples obtained at all harvests.

Results

Yield

Clipping management was the most significant factor affecting forage yield. Simulated grazing produced only 53, 49, and 59 percent as much dry matter as hay management in 1996, 1997, and

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1998, respectively (Table 1). Frequent clipping reduces photosynthetic surface area and thus reduces growth. The longer clipping interval of the hay clipping treatment allowed a much larger photosynthetic area to produce growth.

Average hay yield declined from 12,520 lb/acre in 1996 to 9,320 and 8,510 lb/acre in 1997 and 1998, respectively. Pasture yields declined even more dramatically in 1997, but recovered to 1996 levels in 1998. Variability in pasture yield is due in part to differences in first cutting harvest date. The first cutting in 1996 pasture treatments was delayed until May 31 to allow development of newly established plants. First cutting in 1997 was May 21, and first cutting was delayed until June 16 in 1998 following exceptionally wet conditions. The percentage of total season yield in the first cutting increased from 29 percent in 1996 to 60 percent in 1998.

Relative yield among entries changed over years. In 1996, Matua was the highest yielding entry under both hay and simulated grazing management. The next three highest yielding entries under hay management in 1996 were tall fescue entries, ISI-9077, ISI-8872, and AU Triumph. Kemal, a *Festulolium*, was not significantly lower yielding than the three highest yielding tall fescues in the first year of the trial. In 1997, yields of Matua, Gala, Kemal, and all three perennial ryegrass varieties declined to roughly one-half of 1996 levels under both clipping systems. Yields of these species remained significantly lower than 1996 yields in 1998.

Tall fescue was the highest producing species in the trial in both 1997 and 1998, and over three years because of dramatic declines in production of Matua, Gala, and Kemal. Orchardgrass produced approximately 1 ton/acre less than tall fescue in each year. Perennial ryegrass produced similar yields to orchardgrass in 1996, but significantly lower yields than orchardgrass in 1997 and 1998.

ISI-9077, ISI-8872, and AU Triumph produced significantly higher yields than all other tall fescue entries in 1996. However, there were no significant differences among tall fescue entries in 1997 or 1998. Barcel and Fuego produced lower yields than other tall fescue varieties in 1996, but these were not significantly different in the two following years. Barcel is noted to be slow establishing. Low yields of Fuego in 1996 resulted from poor establishment, probably from low viability of the seed lot received for the trial. Fuego plots were overseeded in 1996 with seed from another source and plant density increased to acceptable levels.

Lupre, Tekapo, and Comet were the highest producing orchardgrass entries in the trial in 1996 under hay management. Of these three entries, only Comet maintained high levels of production in 1997, yielding 99 percent of 1996 levels. Other orchardgrass entries that maintained hay yields of 90 percent or better of 1996 yields include Bronc, Overland, Potomac, and Cambria. Frequent defoliation under the simulated pasture management regime reduced second year production of orchardgrass more than hay production management. Only Overland maintained production levels above 90 percent of 1996 levels under simulated grazing management. In 1998, Overland remained the second highest yielding orchardgrass entry under pasture management, although yields were not significantly higher than other entries. Comet was the highest yielding orchardgrass entry in 1998 under pasture management, with yields significantly higher than Cambria and Latar.

Forage Quality

Forage quality analyses have not been completed for 1998 samples. The following discussion is based on 1996 and 1997 data only. Forage quality trends were similar across years (Table 2) and are discussed below as two-year means. As observed in forage yield, clipping management was the most significant factor affecting percent protein and TDN. Average percent protein and TDN were 16.8 and 59.0 under clipping management compared with 22.2 and 64.2 percent under simulated grazing. All entries had high forage quality under hay management, with minimum values of 14.0 percent protein and 53.6 percent TDN. Matua produced the lowest protein concentration under grazing. The low protein concentration of Matua is due to high biomass production. Nitrogen uptake and assimilation did not keep up with the rate of forage production. Matua and Gala produced the lowest TDN value under grazing. Matua produced more rapid regrowth than most other entries in the trial, and the resulting older biomass may have resulted in lower digestibility. Gala TDN values were probably low because of low genetic potential. It was not selected for high forage quality and has been criticized by other researchers for low digestibility.

Average forage TDN values for tall fescue were similar to perennial ryegrass and orchardgrass under both hay and simulated grazing management. This was unexpected. Perennial ryegrass is reputed to have higher forage quality than other cool-season pasture grasses and tall fescue is thought to have lower forage quality than either orchardgrass or perennial ryegrass. Under hay management, lower perennial ryegrass TDN values may be explained by different maturity levels of the species involved. Perennial ryegrass tends to be earlier maturing than orchardgrass and tall fescue varieties included in this trial. However, clipping frequency under simulated grazing management was approximately two weeks and differences in maturity would be negligible.

Average forage protein concentration of orchardgrass was slightly higher than perennial ryegrass and tall fescue, under hay management. There was no difference in protein content among the three main species under grazing management.

There was also considerable variability in forage quality within species. The most notable example of this is Barcel tall fescue, which has been selected for high quality. It had an average TDN of 59.4 and 65.4 percent under hay and simulated grazing clipping management, respectively.

Seasonal Trends

Because the clipping frequency of the simulated grazing treatment was approximately every two weeks, seasonal trends in forage growth and quality can be examined. Growth rate is calculated by dividing the dry matter produced by the number of days in the growth period. Trends for the three years were similar, and the average growth rate for all three years is depicted in Figure 1. Growth rate was initially slow in the spring because of cool temperatures. It rose to maximum levels by late June and remained high through mid-July before dropping to one-half the maximum level during late July and early August. This was due to temperatures exceeding optimal levels for cool-season grass growth in late summer. As temperatures cooled in late August, growth rates recovered to former levels. Growth rates declined in late September as temperatures cooled.

Cool-season grass growth responses to temperature may be examined by comparing growth rates during a growth period to the average temperature during that period. The relationship of growth rate and temperature can be determined using regression analysis. This relationship is depicted in Figure 2. Growth rate approached zero as temperatures dropped below 52 °F and increased to an optimal temperature of about 65 °F. As average temperatures rose above 65 °F, growth rates declined. Using this correlation, it is easy to understand the phenomena known as the summer slump, when cool-season grass growth declines even when moisture is not limiting.

Species response to temperature differed. Orchardgrass was more sensitive to cool temperatures than perennial ryegrass and tall fescue (Figure 3). The growth rate curve of perennial ryegrass was lower than the other two main species in the trial and much flatter, reflecting the lower yield potential of this species in the Klamath Basin. Both tall fescue and orchardgrass growth rates declined as mean daily temperatures rose above 65 °F, but tall fescue was more adversely affected by high temperatures than orchardgrass. Growth rates of all species in the trial, except Matua, declined when mean daily temperatures rose above 65 °F (Figures 3 and 4). Matua growth rates continued to increase slightly as temperature increased, even during the hottest period of the summer (Figure 4). This species holds promise as a forage resource during the summer slump.

Table 1. Effect of clipping management on total forage yield of cool-season grasses established at KES, Klamath Falls, OR, 1995, harvested 1996, 1997 and 1998. Values represent totals from three and seven to nine harvests for hay and simulated grazing, respectively.

Variety	Species[1]	Hay yield 1996	Hay yield 1997	Hay yield 1998	Pasture yield 1996	Pasture yield 1997	Pasture yield 1998	3-year avg. yield Hay	3-year avg. yield Pasture
		lb/A			lb/A			lb/A	
Gala	BS	13,930	7,420	7,660	8,280	3,060	6,300	9,670	5,880
Matua	BW	19,450	8,440	8,650	11,480	3,880	7,440	12,180	7,600
Kemal	FES	14,880	6,280	6,740	6,570	3,300	6,290	9,300	5,390
BAR 5USF	OG	10,990	9,620	8,400	5,370	4,740	6,840	9,670	5,650
Bronc	OG	10,950	10,640	8,110	6,440	4,880	7,460	9,900	6,260
Cambria	OG	10,470	9,400	7,870	4,490	3,680	5,990	9,250	4,720
Comet	OG	11,240	11,160	8,980	6,040	5,360	7,003	10,460	6,130
Latar	OG	10,570	8,900	8,270	6,310	4,960	7,220	9,250	6,160
Lupre	OG	11,640	8,760	9,090	6,580	4,500	7,040	9,830	6,040
Overland	OG	10,720	10,060	9,100	6,470	6,260	7,120	9,960	6,620
Pizza	OG	10,880	8,960	8,690	6,080	4,360	6,740	9,510	5,730
Potomac	OG	10,790	9,960	8,540	6,190	5,140	6,430	9,760	5,920
Tekapo	OG	11,290	8,980	8,100	5,920	3,700	6,110	9,460	5,240
Mean OG		10,950	9,640	8,520	5,990	4,760	6,800	9,700	5,850
BG3	PRG	11,630	4,320	4,520	5,040	1,700	3,820	6,820	3,520
Moy	PRG	10,960	6,320	4,670	6,010	2,660	4,810	7,320	4,490
Zero-nui	PRG	11,660	5,240	5,870	6,060	2,620	4,340	7,590	4,340
Mean PRG		11,420	5,290	5,020	5,700	2,330	4,320	7,240	4,120
AU Triumph	TF	15,110	11,180	10,010	9,080	5,360	8,460	12,100	7,630
Barcel	TF	12,370	11,620	9,590	5,400	4,280	8,560	11,190	6,080
Desperado	TF	13,820	10,660	11,060	6,630	5,220	8,950	11,850	6,930
Dovey	TF	13,820	11,000	9,650	7,620	5,080	7,560	11,490	6,750
Fawn	TF	14,190	12,200	9,300	6,670	6,360	8,180	11,900	7,070
Fuego	TF	8,630	10,740	10,680	3,530	5,560	8,830	10,020	5,970
ISI-8872	TF	15,230	10,840	10,040	8,060	6,320	8,230	12,040	7,540
ISI-9077	TF	15,320	11,020	10,710	6,880	5,780	8,250	12,350	6,970
Mean TF		13,560	11,160	10,130	6,730	5,500	8,380	11,620	6,870
Mean		12,520	9,320	8,510	6,550	4,530	7,000	10,120	6,030
LSD (p = 0.05)		570	1,640	1,320	180	750	800	950	607
CV (%)		14	10	9	38	10	7	10	11

[1]/ *Bromus stamineus (BS), B. willdenowii,* (BW), *festulolium* (meadow fescue × annual ryegrass)*(FES),* orchardgrass (OG), perennial ryegrass (PRG), and tall fescue (TG).

Table 2. Effect of clipping management on average forage quality of cool-season grasses established at KES, Klamath Falls, OR, August 1995, harvested in 1996 and 1997

Variety	Species[1]	Protein hay	Protein grazed	TDN hay	TDN grazed
		%			
Gala	BS	16.5	22.7	55.0	61.6
Matua	BW	14.2	27.1	55.0	61.6
Kemal	FES	15.4	21.1	57.8	64.3
BAR 5USF	OG	15.2	21.8	57.1	64.4
Bronc	OG	15.8	22.2	58.1	64.8
Cambria	OG	16.4	22.4	57.2	64.8
Comet	OG	15.9	21.8	58.3	64.2
Latar	OG	15.7	22.4	57.6	63.9
Lupre	OG	15.5	22.6	55.9	64.5
Overland	OG	15.4	21.7	56.3	63.0
Pizza	OG	15.5	22.7	57.7	64.4
Potomac	OG	15.5	22.1	56.9	64.5
Tekapo	OG	15.7	21.8	55.9	63.6
Mean OG		15.7	22.2	57.1	64.2
BG3	PRG	16.3	22.0	60.0	65.5
Moy	PRG	15.7	20.7	58.0	63.8
Zero-nui	PRG	15.2	20.7	57.2	63.6
Mean PRG		15.7	21.1	58.4	64.3
AU Triumph	TF	15.7	20.8	58.9	63.3
Barcel	TF	16.6	21.4	59.4	65.4
Desperado	TF	15.4	20.7	58.8	64.2
Dovey	TF	14.8	19.9	57.3	62.2
Fawn	TF	15.4	21.2	57.6	63.8
Fuego	TF	--	--	--	--
ISI-8872	TF	15.4	20.8	58.0	63.7
ISI-9077	TF	15.4	20.1	58.0	63.0
Mean TF		15.6	20.9	58.5	63.9
Mean		15.6	21.5	57.6	63.9
LSD (p = 0.05)		0.6	0.9	0.7	1.4
CV (%)		12	7	2.0	3

[1]/*Bromus stamineus (BS), B. willdenowii,* (BW), *festulolium* (meadow fescue × annual ryegrass), orchardgrass (OG), perennial ryegrass (PRG), and tall fescue (TG)

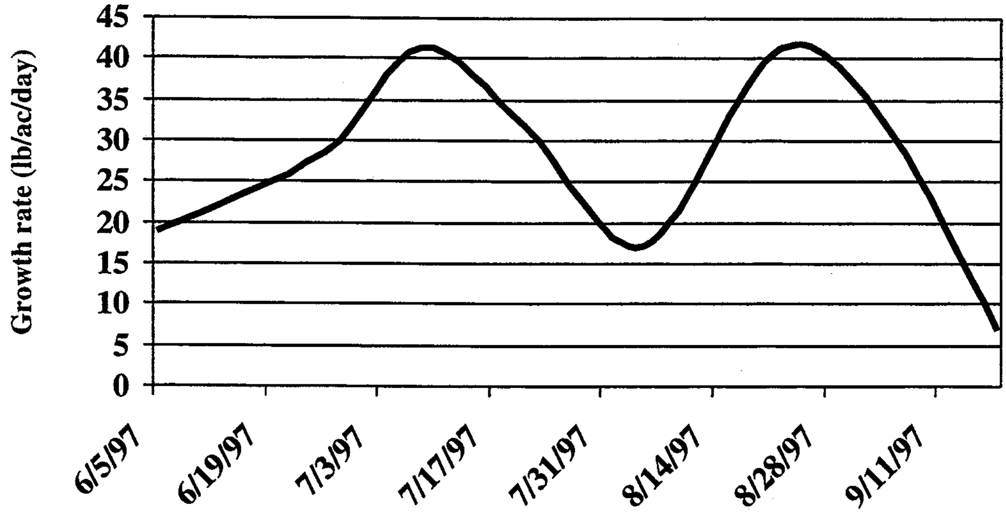

Figure 1. Average growth rate (lb dry matter/acre/day) for cool season grasses grown at Klamath Experiment Station from 1996 to 1998.

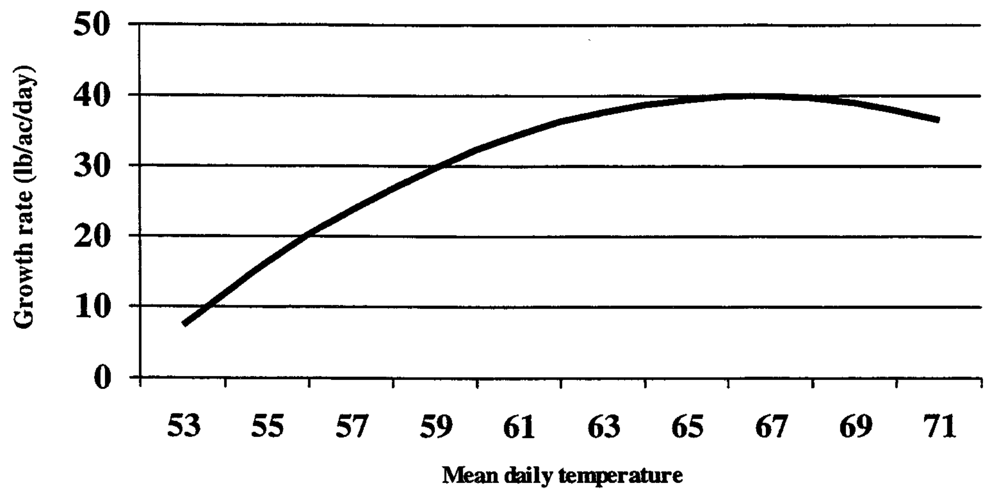

Figure 2. Mean daily temperature effect on growth rate (lb dry matter/acre/day) of cool season grasses grown at Klamath Experiment Station from 1996 to 1998.

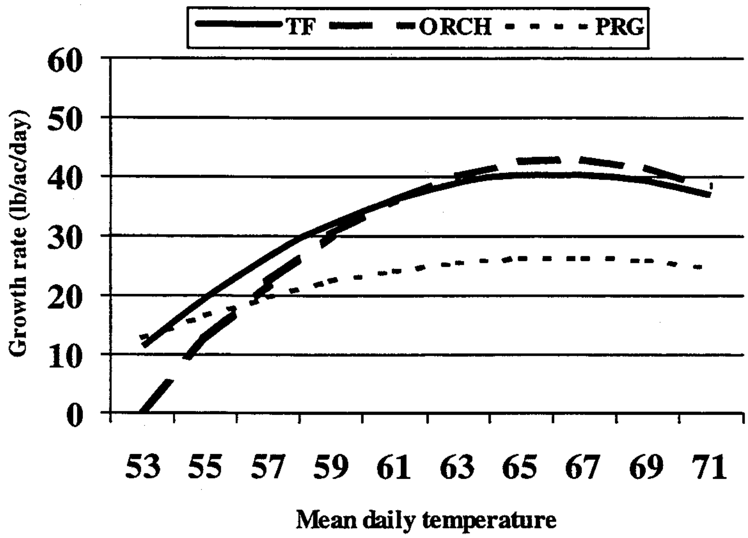

Figure 3. Mean daily temperature effect on growth rate (lb dry matter/acre/day) of tall fescue,orchardgrass, and perennial ryegrass grown at Klamath Experiment Station from 1996 to 1998.

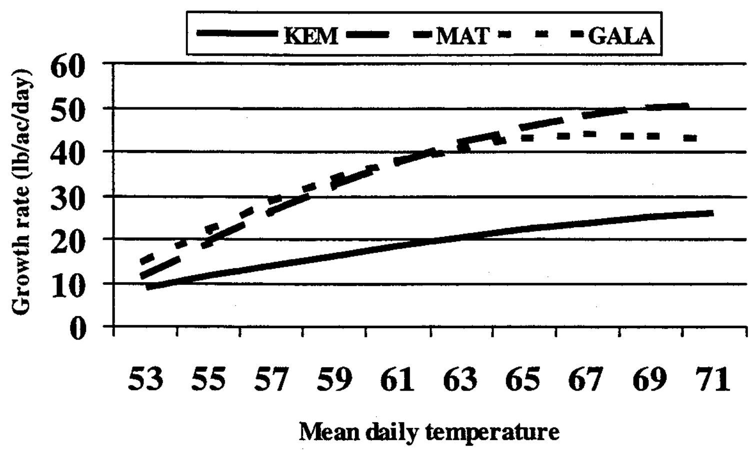

Figure 4. Mean daily temperature effect on growth rate (lb dry matter/acre/day) of Kemal Festulolium, Matua prairiegrass, and Gala grazing brome grown at Klamath Experiment Station from 1996 to 1998.

Forage Selenium Supplementation in Pastures, 1998

R.L. Dovel[1] and Ron Hathaway[2]

Introduction

Forage in the Pacific Northwest is often deficient in selenium (Se) and Se deficiency in livestock is common in the area. Acute deficiencies result in nutritional myopathy, which is commonly called "white muscle disease". Less severe deficiencies contribute to unthriftiness in yearling and adult cattle. Weight gain is depressed, and animals may develop profuse diarrhea. Lower conception rates and reproductive complications also have been attributed to low Se diets.

Selenium supplementation by oral salts and injections has increased weight gain and general health of ruminants on low Se diets and have been widely adopted by ranchers. However, injections are expensive and require frequent handling of livestock. Mineral salt supplements are not easily administered. Free choice feeding of mineral salt supplements generally results in non-uniform doses, with some animals receiving insufficient Se. It would be preferable for animals to receive the appropriate amount of Se in the forage consumed.

Research in Australia and New Zealand has shown that Se fertilizer applied directly to pasture is a suitable alternative to traditional means of Se supplementation. Application of 200 g sodium selenite elevated pasture Se concentration to acceptable levels (about 100 ppb) in New Zealand pastures. Such low rates of Se fertilization do not pose a hazard to the environment through leaching and runoff, and forage produced is well below toxic levels (2, 000-5,000 ppb). Application of Se fertilizer is currently conducted on a commercial scale in Australia and New Zealand. Currently, there is no information on the effectiveness of soil-applied Se in relieving Se deficiency in southern Oregon. Research is needed to verify the effectiveness of such a practice in this environment and to establish appropriate application rates for southern Oregon soils. The frequency of application needed to maintain sufficiency levels in forage can be determined by monitoring Se concentrations over time. A series of experiments was initiated at the KES in 1996 to evaluate the feasibility of selenium fertilization in pastures deficient in selenium and determine the appropriate rate of selenium application in mineral soils.

Procedures

In 1996, an experiment was initiated at KES on an established stand of Oahe intermediate wheatgrass. In 1997, the trial was continued at the wheatgrass site and another initiated on established AU Triumph tall fescue pasture. Selcote, a

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commercially available soil amendment from New Zealand was applied at 0, 0.5, 1, 2, and 4 lb/acre, resulting in an application of 0, 2.25, 4.5, 9, and 18 g Se per acre. Plots measured 5 x 20 ft. Treatments were applied in early April before the initiation of rapid growth. Soil and plant tissue samples were collected before fertilization and analyzed for Se content. Plots were harvested on a three cutting schedule, which is common in the area. Forage was harvested with a Carter flail chopper. Plot wet weights were measured, and subsamples taken to determine dry-matter content. Forage samples were collected for laboratory analysis at each cutting. Plots will be monitored for two years to determine residual effects of Se application in the following year. Sampling will cease when enhanced Se levels are no longer detected in treated plots. Se concentration was determined in nitricperchloric acid digests and subsequent fluorimetry. Data were analyzed using both regression analysis and analysis of variance procedures.

Results

Intermediate Wheatgrass

Results were similar in both 1996 and 1997, and averages of the two years will be used in the following discussion. Selenium application to pasture resulted in increased forage Se concentration. Se concentration in the untreated control averaged 26 ppb, below the critical level for animal health (100 ppb). Selenium concentration in supplemented plots was highest in the first cutting and declined as the season progressed (Figure 1). Application of 1 lb Selcote per acre increased forage Se concentrations above 100 ppb in harvests 1 and 2, but by the third cutting forage Se concentrations declined to 38 ppb. Only the 4 lb Selcote application maintained forage Se concentrations above 100 ppb at the third cutting. Subsequent sampling in the spring of 1997 and 1998 indicated that Se levels of all treatments were equivalent to the untreated control. Maximum forage Se concentration was 400 ppb, well below toxic levels of 2,000 to 5,000 ppb.

Se did not affect forage yield (Table 1). This is in agreement with other researchers. Se is not a plant nutrient and Se concentration in the forage has little or no effect on the plant.

Total Selenium recovered in the first year was never higher than 9 percent of the amount applied (Figure 3). Percentage recovered Se declined with increasing rates of Se supplementation. Low forage Se concentrations in the second year following supplementation indicated that additional Se recovery will be minimal. This is in agreement with findings in Australia and New Zealand where pasture Se supplementation is an annual occurrence. Se may be adsorbed onto soil particles, bound in soil organic matter, leached out of the rooting zone, and even volatilized.

Tall Fescue

Se treatments had no effect on forage production in any cutting or in total yield (Table 2). Tall fescue plots adjacent to the intermediate wheatgrass trial had higher initial Se concentrations than seen in the intermediate wheatgrass trial (Figure 2). Application of 4 lb Selcote/acre resulted in Se concentrations of 876 ppb at the first cutting. However, Se concentration declined more rapidly in tall fescue than in intermediate wheatgrass. Se concentration in the 4-lb treatment declined to 53 ppb by the third cutting, dropping below critical levels for optimal animal performance.

The percent of applied Se recovered in harvested forage was higher in tall fescue than the intermediate wheatgrass trial, averaging 14.3 percent. Percentage of Se recovery was not affected by amount of Se applied.

Conclusions

It appears that pasture supplementation with 1.0 to 2.0 lb Selcote per acre (4.5 to 9 g Se/acre) will elevate forage Se concentrations to levels acceptable for animal health without posing danger to livestock or wildlife. However, additional studies examining the environmental fate of applied Se are needed to determine any hazards posed by Se pasture supplementation to ground and surface waters. There may be species differences in the rate of Se uptake and efficiency of utilization of soil applied Se. Additional evaluation of species responses to pasture Se supplementation is needed.

Table 1. Effect of selenium (Se) supplementation on forage yield of intermediate wheatgrass grown on Se-deficient soil and supplemented with Selcote soil amendment. Klamath Experiment Station, Klamath Falls, OR. Values represent an average of 1996 and 1997 yields.

	Average 1996-97 Forage yield (lb/acre)			
Treatment (lb/acre)	Cut 1	Cut 2	Cut 3	Total
None	4120	1310	1660	7100
Selcote - 0.5	3610	1110	1890	6600
Selcote - 1.0	3800	1250	1710	6760
Selcote - 2.0	3990	1400	1790	7190
Selcote - 4.0	4220	1330	1800	7350
Mean	3950	1280	1770	7000
CV (%)	9	10	7	7
LSD (p = 0.05)	NS	NS	NS	NS

Table 2. Effect of selenium (Se) supplementation on forage yield of tall fescue grown on Se-deficient soil and supplemented with Selcote soil amendment in 1997. Klamath Experiment Station, Klamath Falls, OR.

	1997 Forage yield (lb/acre)			
Treatment (lb/acre)	Cut 1	Cut 2	Cut 3	Total
None	6130	3270	1440	10840
Selcote - 0.5	5300	3880	1390	10570
Selcote - 1.0	5140	4510	1490	11130
Selcote - 2.0	5680	3060	1290	10040
Selcote - 4.0	6810	4210	1300	12330
Mean	5810	3790	1380	10980
CV (%)	9	22	9	9
LSD (p = 0.05)	NS	NS	NS	NS

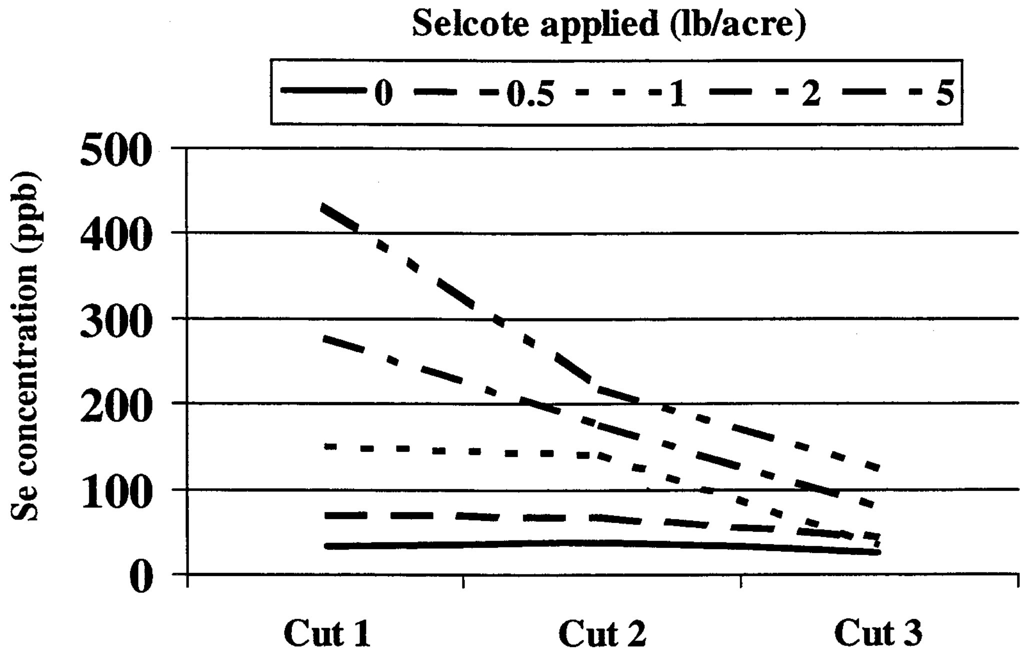

Figure 1. Effect of Se supplementation and cutting date on forage selenium (Se) concentration in intermediate wheatgrass grown on Se-deficient soil in Klamath County, OR. Values represent an average of 1996 and 1997 data.

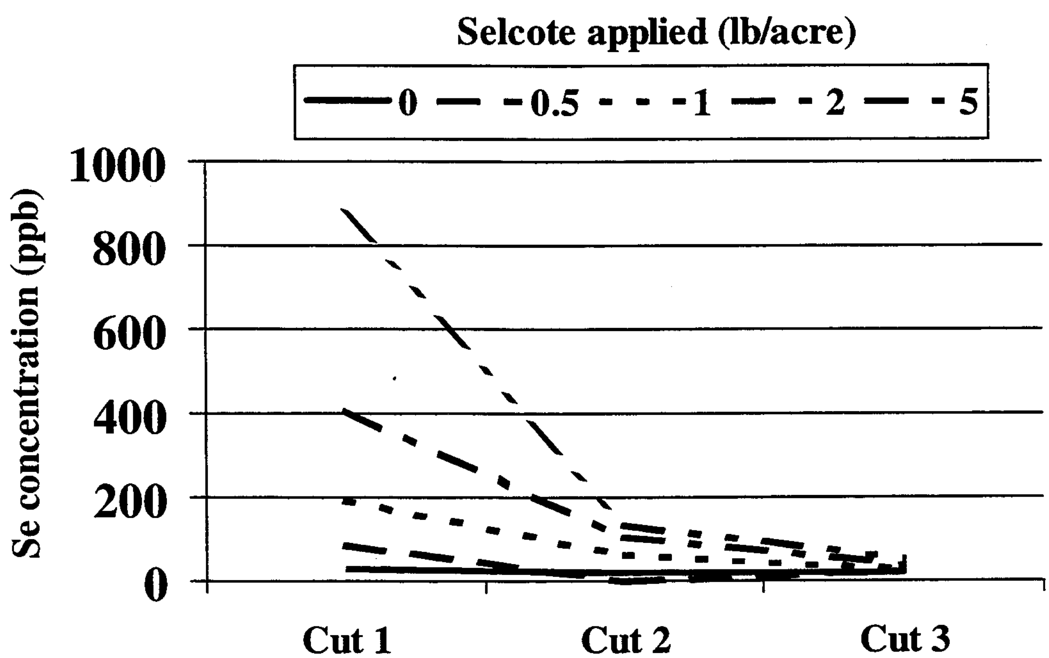

Figure 2. Effect of Se supplementation and cutting date on forage selenium (Se) concentration in tall fescue grown on Se-deficient soil in Klamath County, OR. Values represent 1997 data.

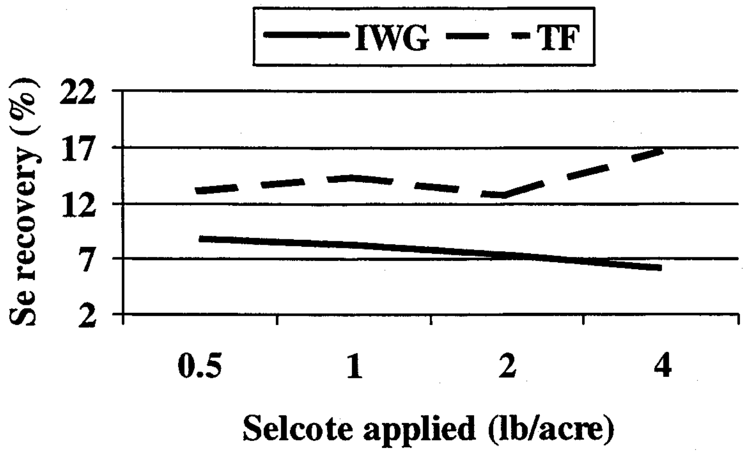

Figure 3. Effect of Se supplementation on recovery of applied selenium (Se) on intermediate wheatgrass (IWG) and tall fescue (TF) grown on Se deficient soil in Klamath County, OR. Intermediate wheatgrass values represent an average of 1996 and 1997 data and tall fescue values are based on 1997 data.

Utilization of Goats to Control Leafy Spurge, 1998

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Introduction

Leafy spurge (*Euphorbia esula* L.) is an aggressive perennial herb that cattle and horses generally don't graze. If grazed by cattle or horses, it causes severe irritation of the mouth and digestive tract and even death. Cattle even avoid palatable grasses growing near this weed. It has reduced the carrying capacity of infested rangeland by 50 to 75 percent. Economic losses because of this weed in the western states is estimated to exceed $150 million annually.

Leafy spurge has taken over millions of acres of western grazing land. It is now well established in a few isolated sites in Klamath County, Oregon. Efforts to contain this weed are underway, but control options are costly and often ineffective.

Research from North Dakota indicates that 2,4-D, dicamba (Banvel), and picloram (Tordon 22K) are the most effective herbicides in controlling leafy spurge. Picloram is not used in Klamath County because it is too costly for widespread use, it is deadly to potatoes, which is a major crop in the county, and it is very persistent in soils. The two remaining herbicides have proven less effective in controlling leafy spurge. The plant is resistant to chemical control because of extensive root systems. Roots may grow up to 15 feet deep and contain abundant nutrient reserves, which enable the plant to recover from stress, including chemical control efforts. The depletion of nutrient reserves in the roots could greatly enhance herbicide effectiveness.

While cattle avoid leafy spurge, goats prefer it to grass and will consume large quantities of the weed. Regrowth following grazing utilizes root reserves and continued defoliation and regrowth will make the plant more susceptible to herbicide attack. Studies in North Dakota and Montana confirm the effectiveness of such integrated control efforts in those environments. Study is needed to document the efficacy of an integrated control program in southern Oregon.

Procedures

Plots were established in southern Klamath County on rangeland infested with leafy spurge. The study was arranged in a split plot design with four replications. The main plot was grazing treatments. Eight exclosures measuring 75 by 75 feet were constructed. Four exclosures were rotationally grazed by goats. Leafy spurge plants were severely defoliated three times during the growing season. Goats were added or subtracted

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as needed to adequately defoliate the leafy spurge without overgrazing the grasses in the exclosure. Grazing was excluded from the four remaining exclosures during the growing season. The area outside the exclosures was continuously grazed by goats at a stocking density of two goats per acre. Goats remained on the pasture through mid-August.

Prior to the initiation of each rotational grazing cycle, leafy spurge plant density, leafy spurge biomass, and grass biomass was determined using random samples measuring 0.25 m^2. Rotationally grazed plots were sampled before grazing (Rotational-In) and after a two-day grazing period (Rotational-Out). Leafy spurge leaves and stems were separated and percentage of leaf was determined. Exclosures were removed in the fall after goats were removed, and the entire area was grazed by cattle to utilize the accumulated forage resource.

Herbicide treatments were applied in the spring of 1998 before seed set. Treatments were applied to all three grazing treatments. Treatments included an untreated control, 2,4-D, dicamba, Krenite, and picloram at labeled rates. Data on herbicide efficacy will be collected in the spring of 1999.

Statistical analysis was performed using analysis of variance procedures.

Results

Goat grazing behavior and grazing effects on leafy spurge and grasses were similar in 1997 and 1998. Data presented below is a composite of the two years.

Goats were introduced to the leafy spurge infested pasture on June 1 and began to preferentially graze leafy spurge plants after two to three days. When introduced to a new feed source, goats often require an adjustment period before they begin to actively feed on the new forage resource. Once the goats were accustomed to leafy spurge, the flock was introduced into the rotationally grazed paddocks. They were removed the evening of the second day of grazing. The goats readily consumed the leafy spurge in the rotationally grazed paddocks, leaving very few stems and almost no leaves (Figure 1 and Table 1). Leafy spurge was consumed at a slower pace in the continuously grazed plots because of a more extensive area. However, by the second sample date, leafy spurge biomass was reduced to one tenth the amount in ungrazed paddocks and significantly lower than rotationally grazed paddocks, which had experienced a substantial amount of regrowth (Figure 1). When goats were reintroduced to the rotational plots following the second sample date they quickly brought leafy spurge biomass down to continuously grazed levels. A similar pattern was observed at the third sample date. Both continuous and rotational grazing eliminated leafy spurge seed production.

Percentage of leaf following rotational grazing was very low. However, in the absence of goats, the plants quickly produced more leaves, resulting in a higher percentage of leaves in rotationally grazed paddocks at the mid-July sample date (Figure 2). Two days later following grazing, percent leaf of rotationally grazed paddocks were the lowest in the trial. In contrast, continuous grazing resulted in a slower decline of the percentage of leaf with no recovery period.

Leaf area was not measured, but leaf mass was determined and accurately reflects trends in photosynthetic area. Although percentage of leaf increased rapidly during the rest period following rotational grazing, the actual amount of leaves (g/m^2) remained low (Figure 3). Immediately following the early June defoliation, there was much less leafy spurge leaf material in the rotational compared to continuously grazed plots. However, leaf mass increased to roughly 30 g/m^2 by mid-July. Following the mid-July defoliation, rotational grazing reduced leaf mass to levels equivalent to continuously grazed plots. During the final rest period, leaf mass increased in rotationally grazed plots and declined to levels equivalent to continuously grazed plots following mid-August grazing. There was probably some replenishing of root reserves in rotationally grazed plants during the rest period between grazing. A more frequent grazing interval would result in less photosynthetic area for replenishing root reserves.

Grazing also affected leafy spurge density as expressed by stems per m^2. Rotational grazing decreased leafy spurge stem density to less than one-half pregrazing levels in only two days (Figure 4 and Table 1). Stem density of rotationally grazed paddocks did not increase during the rest period between grazing events. Stem density of continuously grazed paddocks were one-fifth ungrazed levels and one-half rotationally grazed levels at both the mid-July and mid-August sample dates.

Both grazing treatments resulted in greater accumulated grass biomass than the ungrazed control. At least twice as much grass was available for fall cattle grazing where goats had grazed (Figure 5). Residual grass biomass was slightly higher in continuously grazed paddocks than the rotationally grazed paddocks following the final grazing before goat removal.

It is clear that goat grazing reduced leafy spurge biomass, increased available grass biomass for fall grazing, and generally shifted the competitive advantage in favor of the grass species on the site. It is not known if continued goat grazing will significantly reduce the leafy spurge population in this environment. Further monitoring and study is needed to determine the long-term effectiveness of goat grazing in reducing leafy spurge in southern Oregon pastures and rangelands. Application of chemical treatments and subsequent monitoring will also provide information on the efficacy of an integrated goat-grazing, herbicide control program.

Table 1. Average of 1997 and 1998 grazing treatment effects on leafy spurge stand density, leafy spurge biomass, leafy spurge percent leaf, and grass biomass across the growing season. Goats were introduced to the plot area following the early June sampling date.

Sample date	Grazing treatment	Spurge density stems/m^2	Spurge biomass g/m^2	Percent leaf %	Grass biomass g/m^2
Early-June					
	Non-grazed	271	50	63	35
	Continuously grazed	276	54	67	33
	Rotational-In	267	47	62	37
	Rotational-Out	118	19	12	25
	Mean	233	42	51	32
Mid-July					
	Non-grazed	274	190	55	30
	Continuously grazed	53	14	17	71
	Rotational-In	98	48	64	83
	Rotational-Out	90	16	11	52
	Mean	128	67	37	59
Mid-August					
	Non-grazed	276	203	50	28
	Continuously grazed	45	16	10	61
	Rotational-In	111	36	72	64
	Rotational-Out	78	15	18	48
	Mean	128	67	38	50
	Mean	163	59	42	47
	LSD (p = 0.05)	24	8	5	9

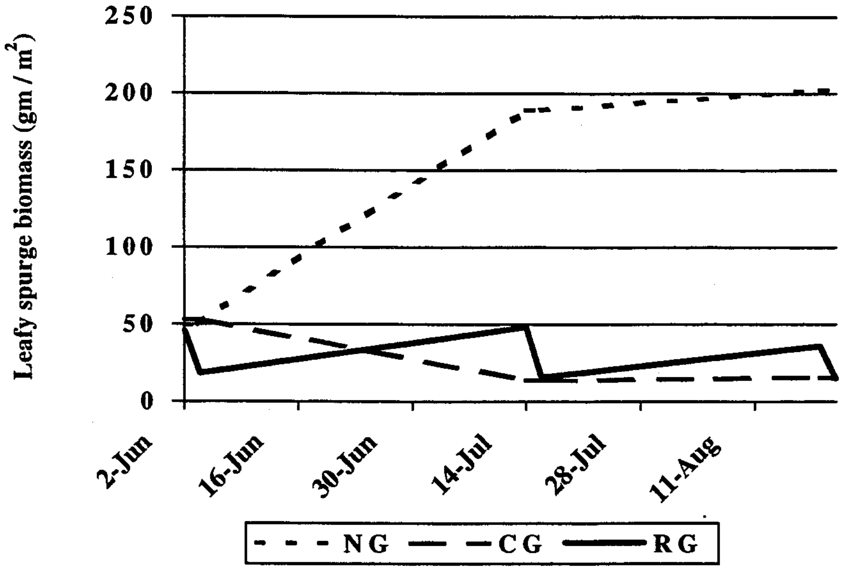

Figure 1. Effect of no grazing (NG), continuous grazing (CG), and rotational grazing (RG) on leafy spurge biomass on a leafy spurge infested site in southern Klamath County. Values represent an average of 1997 and 1998 data.

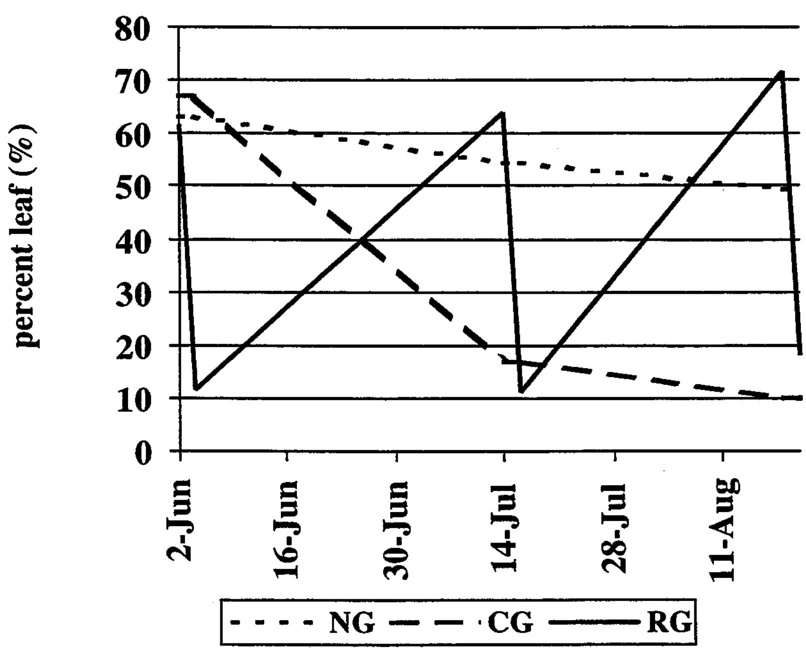

Figure 2. Effect of no grazing (NG), continuous grazing (CG), and rotational grazing (RG) on leafy spurge percent leaf on a leafy spurge infested site in southern Klamath County. Values represent an average of 1997 and 1998 data.

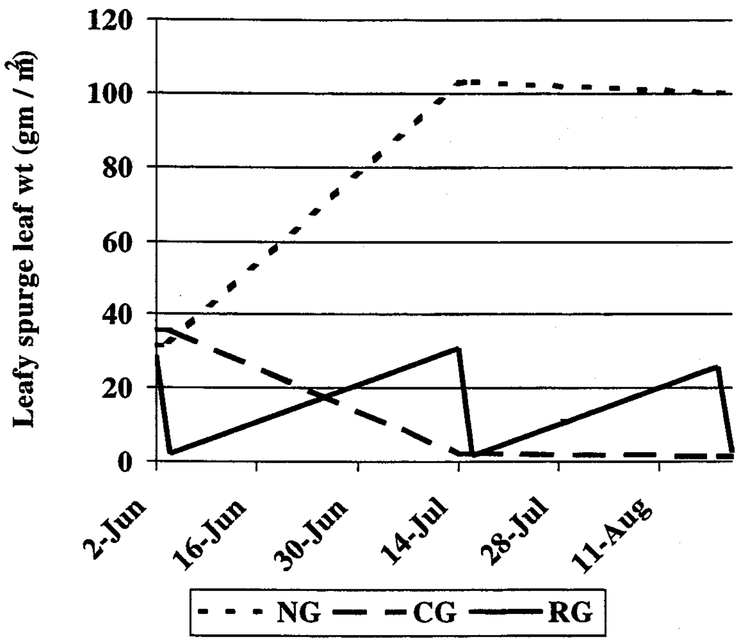

Figure 3. Effect of no grazing (NG), continuous grazing (CG), and rotational grazing (RG) on leafy spurge leaf weight on a leafy-spurge-infested site in southern Klamath County. Values represent an average of 1997 and 1998 data.

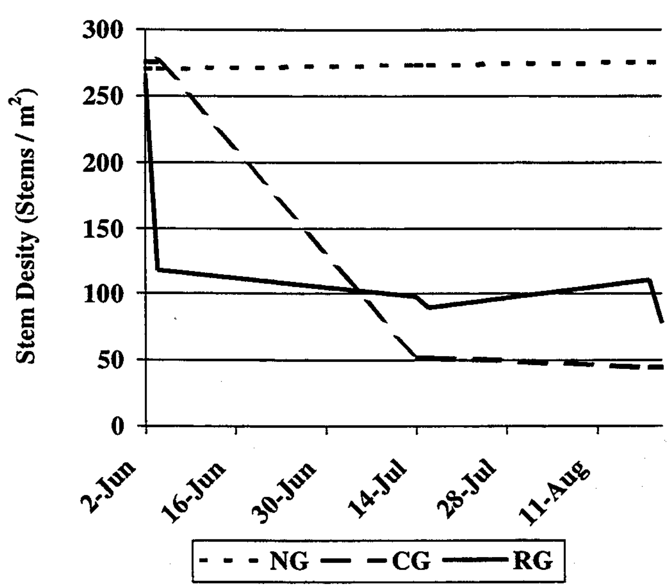

Figure 4. Effect of no grazing (NG), continuous grazing (CG), and rotational grazing (RG) on leafy spurge stem density on a leafy-spurge-infested site in southern Klamath County. Values represent an average of 1997 and 1998 data.

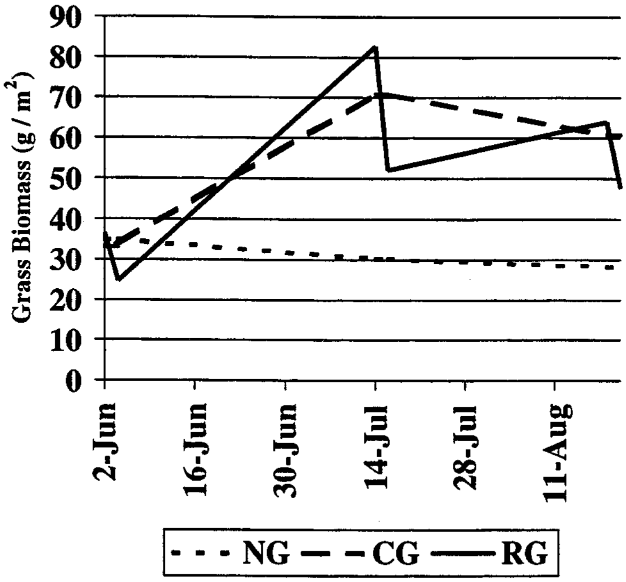

Figure 5. Effect of no grazing (NG), continuous grazing (CG), and rotational grazing (RG) on grass biomass on a leafy spurge infested site in southern Klamath County. Values represent an average of 1997 and 1998 data.