Special Report 1042
July 2002

Research in the Klamath Basin
2001 Annual Report

in cooperation with Klamath County

OREGON STATE UNIVERSITY
AGRICULTURAL EXPERIMENT STATION

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Agricultural Experiment Station
Oregon State University
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Note from the Superintendent

The year 2001 will long be remembered for the extreme conditions imposed on the Klamath Basin agricultural community. A serious drought in the region became evident by mid summer 2000. Total precipitation at Klamath Falls from March 2000 through October 2001 was about 55 percent of normal. Net inflow to Upper Klamath Lake from April 1, 2001 through September 31, 2001 was about 200,000 acre-ft; about 40 percent of historical average inflow. This was greater than inflows during droughts in 1992 (155,000 acre-ft) or 1994 (179,000 acre-ft) when most Klamath Reclamation Project lands received near normal irrigation deliveries.

The drought of 2001 was compounded by Federal regulatory actions intended to provide habitat needs for protection of Federally listed threatened and endangered species in the Klamath River and Upper Klamath Lake. Biological Opinions released by the National Marine Fisheries Service (NMFS) and the United States Fish and Wildlife Service (USFWS) on April 6, 2001, required minimum river flows and lake elevations that exceeded projected available storage and inflows to Upper Klamath Lake. To comply with these conditions, the Bureau of Reclamation's Klamath Project 2001 Operations Plan precluded diversion of irrigation supplies from Upper Klamath Lake and Klamath River, leaving about 170,000 acres within the Klamath Reclamation Project with no surface water supply for 2001.

The Klamath Experiment Station (KES) does not have well water. With the exception of cover crops for erosion protection on bare fields, crops were not planted at KES in 2001. A deep drain at KES provided sufficient irrigation water for maintaining about 1 acre of forage trials established in 2000. Two off-station fields provided limited research opportunities. Cereal variety trials were conducted at a Lower Klamath Lake site that received winter flooding but no irrigation during the growing season. Potato and cereal trials also were conducted at a site 25 miles east of Klamath Falls with well water irrigation. This report presents the results of our efforts at these locations.

The "Klamath Crisis" as the irrigation project situation became known, received national recognition and attention. Oregon State University (OSU) and the University of California faculty members embarked on an ambitious task to document the consequences of denial of irrigation supplies on the citizens, natural resources, and economy of the region. A team of about 20 university faculty developed extensive materials to describe social, economic, and natural resource responses to the crisis and a partial historical perspective. KES faculty participated as co-authors of chapters on "An Overview of the Klamath Reclamation Project and Related Upper Klamath Basin Hydrology" and "Soil Resources in the Klamath Reclamation Project. We also were reviewers of other chapters and participants and organizers of several tours of the region. A final report from the team is expected to be released by July 2002.

KES hosted the OSU Agricultural Experiment Station (AES) Summer Tour on August 1, providing a 3-hour bus tour of the Klamath Reclamation Project to 45 participants. Local producers and agri-business personnel joined the tour group for lunch and an opportunity to hear first-hand stories of the effects of the water curtailment.

Having spent 15 years working closely with many individuals affected by the situation, I could appreciate the anguish of families whose lives were severely affected by actions uninfluenced by the economic consequences of political decisions. I welcomed the opportunity to provide information in several venues, including written and oral presentations to a National Academy of Sciences National Resource Council (NRC) review team, appointed to review the science behind the Biological Opinions. It was very gratifying to me personally, and to the agricultural community, when the NRC issued a draft preliminary report on February 4, 2002 stating that minimum river flows and lake elevations required by the 2001 Biological Opinions could not be justified by the available science.

The long-term prognosis for Klamath Reclamation Project irrigators remains uncertain. Biological Opinions issued by NMFS and USFWS for 2002-2011, while acknowledging the NRC preliminary report and findings, continue to call for higher river flows and lake levels than the regional hydrology can support without significant changes in project operations.

KES has served the agricultural community since the late 1930's. Our projects have been instrumental in developing superior varieties of crops for the region and cultural practices to optimize crop performance and minimize losses to pests and diseases. Reclaiming saline/saline sodic soils, developing nutritional supplements for livestock, improving irrigation technology, and assisting in the introduction of new crops have been traditional roles for KES programs. In the current climate of uncertainty, however, the role of the KES in supporting the region's agricultural industry must be reevaluated. If irrigation security is not assured, fine-tuning of cultural management practices, releasing superior crop varieties, and developing improved disease or pest management technology will be of little value.

During the next two years, KES staffing and research priorities need to be evaluated to develop a plan for the future. Traditional agronomic research will continue to be needed; but watershed management, water quality issues, and development of more water-efficient production techniques likely will present opportunities for an expanded role in finding solutions for long-term survival of a viable and sustainable industry in concert with environmental objectives. The timing for such a review is appropriate, as I will be retiring on June 30, 2004. The selection of my successor will be an important factor in future directions for KES research programs and contributions.

We hope our clientele, collaborators, and other interested parties find our 2001 Annual Research Report interesting and useful. This is the 15th consecutive KES Annual Report of our programs and progress. We welcome any suggestions for improvements. We extend our appreciation to our colleagues who cooperate in research activities, industry and organizations who provide financial support for research projects, members of our station Advisory Board for their counsel, and to Klamath County for continuing financial support for staffing, facilities, and equipment. Where appropriate, cooperators and financial support are acknowledged in project reports. For those with an interest in KES research reports from earlier years, printed copies of Annual Reports for most years from 1987 through 2000 are available by request from: kenneth.rykbost@oregonstate.edu.

Those with Internet access can review annual reports for 1999-2000 and other information about the Klamath Basin on our Internet Web page at: http://www.orst.edu/dept/kes.

I extend thanks on behalf of KES, OSU, our clientele, and me personally, to our staff for their efforts and dedication during a very difficult year. Uncertainty for the future of Klamath Basin agriculture and for budget support for OSU, the AES, and KES, created a climate of instability and concern. Our staff overcame many obstacles to continue viable research projects, produce reports and publications, and maintain the infrastructure to meet future challenges.

We welcome our newest permanent employee, Efren Valencia, to his position as Farm Worker, funded by Klamath County. Efren served as a seasonal employee in two previous years and has gained experience with many of our field and laboratory procedures. Special thanks to Jewel Haskins, our Office Specialist II, for assembling and formatting this report.

Kenneth A. Rykbost

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, 2001

Kenneth A. Rykbost, Brian A. Charlton, and Donald R. Clark[1]

The Klamath Basin of southern Klamath County, Oregon and northern Modoc and Siskiyou counties, California enjoys a semi-arid climate with average annual precipitation of about 13 in at Klamath Falls. The valley floor, at 4,100 ft elevation, is susceptible to frost any day of the year and typically experiences a frost-free season of less than 100 days. In 3 of the last 10 years, at least one frost has been recorded in each month at the Klamath Experiment Station (KES). South of Klamath Falls, the Lower Klamath Lake and Copic Bay areas experience minimum temperatures 5 to 7°F cooler than temperatures recorded at KES.

Economical agricultural enterprises in the region depend on supplemental irrigation for crop production other than rangeland, pastures, and meadow hay. In the late 1800's, conversion of the region to agricultural use commenced with the development of privately owned irrigation projects. In 1905, the U.S. Bureau of Reclamation purchased most of the private irrigation companies and initiated the construction of the Klamath Irrigation Project (KIP) to service about 240,000 acres in the upper basin. By about 1960, the project was fully developed. In recent years, the KIP has provided irrigation water to about 190,000 to 200,000 acres of cropland annually. Although drought conditions have resulted in less than full water deliveries a few times, major shortages were not experienced in the 95 years of operation through 2000.

Changing allocations of surface water supplies to meet perceived needs of endangered sucker species in Upper Klamath Lake and threatened coho salmon in the Klamath River, combined with drought conditions in the upper watershed, resulted in severe curtailment of irrigation deliveries to KIP properties in 2001. Initially, the KIP 2001 operations plan allocated normal deliveries to about 26,000 acres in the Langell Valley and Horsefly irrigation districts served by Gerber and Clear Lake reservoirs. In late July, about 70,000 acre-ft were diverted to project lands from Klamath Lake and Klamath River. Existing and newly developed wells supplied additional water to small acreages scattered throughout the project. The Klamath County tax assessor estimated that 85,000 acres within project boundaries in Klamath County received less than full irrigation in 2001. This resulted in a major disruption of agricultural activities on about 150,000 acres of KIP cropland, including the KES headquarters.

The U.S. Weather Bureau monitored precipitation at Klamath Falls from 1884 through 1948 (Table 1). National Oceanic and Atmospheric Administration (NOAA) established a station at Kingsley Field in 1949. The Kingsley Field site is located at 42°44' N latitude, 121°44' W longitude, and at an elevation of 4,092 ft. NOAA closed the Kingsley Field station in 1996. The

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

KES weather station, located one-forth mile west of Kingsley Field, has been in operation since 1984 and was designated as the official NOAA Klamath Falls station in 1997.

The U.S. Bureau of Reclamation (BOR) office in Boise, Idaho has established four additional weather stations in the region in the past 3 years as part of a regional Agricultural Meteorological (AgriMet) network. Instrumentation was installed adjacent to the KES NOAA station in April 1999. Stations were established in April 2000 in the Lower Klamath Lake (LKL) area about 15 miles southwest of Klamath Falls and at the northwest shore of Agency Lake at the pumping station for drainage of Agency Lake Ranch (ALR), about 25 miles northwest of Klamath Falls. A fourth AgriMet station was installed in the Langell Valley (LV) near the town of Lorella in April 2001.

The cyclical nature of precipitation patterns in the region can be seen by comparing total annual precipitation at KES from 1991 through 2001 (Table 1). For the first 4 years of this period, average precipitation was 10.82 in. In 1995-1998 the average precipitation was 18.10 in, the highest 4-year average since records began. This period was followed by 3 years of below normal precipitation with an average of 11.03 in. The lowest 4-year period on record was from 1929 to1932. Each year received less than 10.00 in and the 4-year average was 9.34 in during this period.

While total 2001 Klamath Falls precipitation was about 75 percent of long-term averages, this is misleading. Above normal precipitation in November and December accounted for 54 percent of the yearly total, more than twice the typical contribution for these months (Table 2). For the October 1, 2000 to September 30, 2001 water year, total precipitation recorded at KES was 6.69 in. This is less than the total annual calendar-year precipitation for all years of record except 1949.

Mean annual air temperatures in 2001 were only slightly different than long-term averages (Table 2). A comparison of maximum and minimum means for June through September suggests the diurnal fluctuations were greater due to lower relative humidity related to lack of irrigation in the area. This is also evident in the air and soil temperature data for the growing season of April through October from 1970 to 2001 (Table 3). The 39°F diurnal spread in 2001 is greater than in any other year in the data set, in which the average spread is 31^0F. Weekly temperature summaries for April through October show similar trends (Table 4).

The 2001 frost-free season extended 78 days from June 19 through September 5, based on the NOAA KES station. Minimum air temperatures of 33°F were recorded at KES on July 17 and July 31. Frosts were experienced at the LKL AgriMet station on both of these dates. Frequency of frosts at KES was greater in 2001 than the average for the previous 21 years (Table 5). Maximum temperatures at KES reached or exceeded 90°F on 31 days in 2001 with highs of 97°F reached on July 5 and August 9. Precipitation during April through September was the lowest since 1981 (Table 2). Only 0.47 in was recorded from mid-May through early September (Table 5).

The AgriMet network is intended to provide daily crop-specific water-use estimates to assist in irrigation scheduling. These stations monitor soil temperature at 4- and 8-in depths, solar radiation, air temperature, wind speed and direction, and precipitation. Readings taken at 15-minute intervals are stored and transmitted every 4 hours through a geostationary satellite to the BOR coordinating office in Boise, Idaho. Crop water use data are displayed on Internet web pages at the Klamath County Cooperative Extension Service and the KES homepage, or can be obtained from the BOR's regional Hydromet System at http://www.pn.usbr.gov/agrimet.

Observations for the AgriMet stations are based on midnight to midnight reporting. NOAA readings are based on 7:30 a.m. observations. This leads to minor differences in daily observations between the two stations. Mean monthly comparisons of 2001 air temperatures, precipitation, and wind speed for KES, NOAA, and AgriMet stations are presented in Table 6. Minimum air temperatures averaged 3°F lower in 2001 and 4°F lower in 2000 based on NOAA observations. This is probably due to NOAA sensors being located closer to ground level and the time of observation, which can result in minimum temperature at time of observation being applied to the previous and current day for NOAA readings. Annual total precipitation was 3 percent higher for the NOAA station in 2001. In 2000, the NOAA station reported 8 percent greater precipitation. Differences in mean monthly wind speeds were small.

Crop water-use estimates can be based on evapotranspiration (ET) estimates or standard pan evaporation data adjusted for crop canopy stage. The ET values reported in Table 6 are for actively growing alfalfa. Values for row crops and cereals would be considerably lower. For example, seasonal water use for potatoes in the region is about 20 in compared with 30-32 in for alfalfa. Pan evaporation data are collected for the NOAA station from May 1 through September 30. In 1999 and 2000, total pan evaporation for this period measured 38.9 and 38.5 in, respectively. In 2000, the AgriMet ET estimate was 92 percent of pan evaporation. The 2001 ET was only 84 percent of pan evaporation (Table 6). Higher evaporation readings in 2001 were undoubtedly related to low relative humidity resulting from lack of irrigation in the area near the weather station. It was also speculated that birds or mammals were drinking from the evaporation pan in 2001. On several days, pan readings exceeded 0.5 in. In previous years, readings seldom exceeded 0.4 in.

The AgriMet network in the Klamath Basin provides an opportunity to compare temperatures and precipitation in several locations within the region. Mean monthly air temperatures and total monthly precipitation are shown for the four AgriMet stations in Table 7. The LV station was installed at the end of March and does not provide total annual data for 2001.

Microclimate effects on air temperatures are evident in the AgriMet data. The LKL station is situated in a low elevation area that typically experiences summer frosts more frequently than the KES site. From May through October, minimum air temperatures were 5°F lower at LKL than at KES. The ALR station is located immediately adjacent to Agency Lake. Air temperatures are moderated with lower maximums for each month except December compared to KES (Table 7). Minimum temperatures are slightly warmer near the lake during spring months. The LV site experienced similar maximum temperatures to the KES site and was intermediate between KES and LKL sites in minimum temperatures during summer months. Trends in air temperatures at KES, LKL, and ALR sites were similar in 2000.

Total annual precipitation for 2001 recorded at ALR was 28 and 54 percent greater than at KES and LKL, respectively. This was the first full year of data at the sites. In 2000, total precipitation from May through December was 3.33, 3.93, and 3.96 in at KES, LKL, and ALR, respectively. Precipitation at LV was slightly greater than at KES and LKL from April through December.

Daily weather records from the NOAA KES station are available for the past 3 years on the KES Internet Home Page at: http://www.orst.edu/dept/kes. Current weather records are updated daily on weekdays.

For Klamath Basin areas that received irrigation water, the 2001 weather conditions were favorable for crop production. Yields and quality of potato crops were generally good. The only disease problem of significance was pink rot (*Phytophthora erythroseptica*). Damage from this disease was observed in fresh market russet varieties and in round white chipping varieties at several locations, including KES research plots.

Performance of forage crops ranged from total loss of harvestable crops to normal production. A 6-year-old alfalfa trial at KES produced about 1 ton/acre in an unirrigated first cutting. In previous years, first cuttings in this field averaged about 2.5 tons/acre. Following about 5 in of irrigation applied in early August, a second cutting in September produced about 1 ton/acre. Total production from the two cuttings was about 2 tons/acre compared to a 4-year average of 6.5 tons/acre for 1997-2000. Crops on soils with higher moisture holding capacity produced significantly greater yields under dryland conditions.

A 12-acre field of annual ryegrass established in grain stubble with a no-till drill at KES in the fall of 2000 failed to produce a harvestable crop after severe waterfowl grazing in early spring. A small annual ryegrass field at KES planted with conventional tillage and a grain drill in August of 2000, but not subjected to waterfowl grazing, produced a single cutting of about 0.5 ton/acre. Neither field was irrigated in 2001. Pasture production in dryland situations was very limited. A KES pasture in the LKL area that received winter flooding but no summer irrigation supported about 25 percent of the normal stocking rate. Severe overgrazing on some pastures may require renovation to restore productivity.

Dryland cereal crops also experienced wide fluctuations in productivity. Performance of species and varieties in cover crop trials established at KES will be discussed later in this report. Commercial production on high organic matter soils used for potato or onion production in 2000 is reported to have produced barley yields of up to 3 tons/acre with acceptable quality. These fields benefited from residual fertilizer and moisture from the previous crop. Some fields failed to produce harvestable crops. Time of planting, previous crop, soil type, frosts, and locally variable rainfall during the growing season all contributed to the relative performance between fields.

The most serious effect of water supply curtailment on future crops may be the severe weed infestations and resulting seed production that occurred in 2001. While weed control was achieved on some fields, many fields were allowed to produce unchecked weed populations. Weeds also proliferated in irrigation and drain ditches. Seeds produced in these fields and ditches will increase weed control costs for years.

Table 1. Annual precipitation at Klamath Falls, OR, recorded by the U.S. Weather Bureau (1884-1948), National Weather Service (NOAA) (1949-2001), and Klamath Experiment Station (KES) (1984-2001).

Precipitation								
Year	in	Year	in	Year	in	Year	in	
U.S. Weather 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[1]	1927	15.47	1955	11.31	1985	9.17	10.15
1891-99	NA[2]	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	1999	11.54	11.54
1910	14.70	1940	17.12	1970	12.61	2000	11.51	11.51
1911	9.73	1941	19.71	1971	12.68	2001	10.03	10.03
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	1984-2001	12.79

[1]IN: datum incomplete.

[2]NA: datum unavailable.

Table 2. Mean monthly air temperatures and total monthly precipitation recorded at the Klamath Experiment Station, Klamath Falls, OR, for 2001 and for 1984 to 2000.

Month	Mean monthly temperature max	min	mean	Total precipitation
	°F			in
		2001		
January	42	17	30	0.20
February	43	20	31	0.48
March	55	25	40	0.78
April	54	25	40	0.94
May	75	36	55	0.61
June	75	37	56	0.23
July	84	43	64	0.22
August	87	45	66	0.05
September	79	36	57	0.73
October	68	27	48	0.33
November	49	24	36	2.88
December	37	21	29	2.58
Mean/Total	62	30	46	10.03
		1984-2000		
January	40	20	30	1.99
February	44	23	34	1.19
March	52	27	39	1.24
April	59	30	45	0.94
May	66	36	51	1.21
June	74	43	59	0.79
July	83	48	65	0.40
August	83	46	64	0.53
September	76	39	58	0.72
October	65	30	48	0.76
November	47	24	36	1.63
December	39	18	29	1.55
Mean/Total	61	32	47	12.95

Table 3. Mean air temperatures for April through September, mean 4-in soil temperatures for May through October, and total precipitation for April through September and annually from 1970 to 2001 at Klamath Falls, OR.

Year	Air temperature Apr-Sept			4-in soil temperature May-Oct			Total precipitation	
	max	min	mean	max	min	mean	Apr-Sept	annual
	°F						in	
2001	76	37	56	74	59	66	2.78	10.03
2000	72	39	56	70	56	63	4.20	11.51
1999	72	39	55	68	55	61	3.98	11.54
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	67	57	62	4.02	12.61

Table 4. Weekly average maximum, minimum, and mean air temperatures for the 2001 growing season and 1979 to 2000 at Klamath Falls, OR.

Weekly period		2001 Weekly average			1979-2000 Weekly average		
		max	min	mean	max	min	mean
		°F					
April	1-7	51	20	35	55	29	42
	8-14	44	20	32	57	30	43
	15-21	54	29	42	59	33	46
	22-28	68	34	51	59	32	46
	29-5	63	26	44	62	34	48
May	6-12	78	32	55	63	35	49
	13-19	69	37	53	66	36	51
	20-26	84	44	64	69	39	54
	27-2	78	38	58	69	40	55
June	3-9	70	33	52	70	41	56
	10-16	74	34	54	73	43	58
	17-23	85	40	62	76	44	60
	24-30	74	41	58	78	46	62
July	1-7	91	47	69	78	46	62
	8-14	86	45	66	82	48	65
	15-21	78	41	59	83	49	66
	22-28	87	43	65	85	50	68
	29-4	81	42	62	86	49	67
August	5-11	92	50	71	86	49	67
	12-18	91	46	68	83	47	65
	19-25	80	42	61	81	45	63
	26-1	90	44	67	80	43	62
September	2-8	81	37	59	80	43	61
	9-15	80	40	60	77	40	59
	16-22	81	36	59	74	39	56
	23-29	66	35	50	73	38	55
	30-6	81	33	57	73	35	54
October	7-13	66	23	45	68	34	51
	14-20	70	27	48	64	29	46
	21-27	64	22	43	61	30	46
Mean		75	36	56	72	40	56

Table 5. Weekly minimum air temperatures, frost days, and precipitation for the 2001 growing season and 1979 to 2000 at Klamath Falls, OR.

Weekly period		Weekly min.		Frost days/week		Weekly precip.		Accum. precip.	
		2001	1979-00	2001	1979-00	2001	1979-00	2001	1979-00
		—— °F ——		—— % ——		—— in ——			
April	1-7	14	11	100	75	0.20	0.15	0.20	0.15
	8-14	15	15	100	66	0.19	0.17	0.39	0.32
	15-21	20	17	86	50	0.55	0.27	0.94	0.59
	22-28	27	20	43	52	0.00	0.24	0.94	0.83
	29-5	21	19	86	36	0.00	0.27	0.94	1.10
May	6-12	24	18	57	44	0.00	0.21	0.94	1.31
	13-19	29	19	28	33	0.61	0.27	1.55	1.58
	20-26	40	24	0	18	0.00	0.23	1.55	1.81
	27-2	30	27	28	18	0.00	0.31	1.55	2.12
June	3-9	22	26	43	10	0.03	0.26	1.58	2.38
	10-16	25	27	28	7	0.00	0.16	1.58	2.54
	17-23	32	30	28	4	0.00	0.07	1.58	2.61
	24-30	36	31	0	0	0.20	0.13	1.78	2.74
July	1-7	39	31	0	2	0.00	0.08	1.78	2.82
	8-14	40	34	0	0	0.17	0.04	1.95	2.86
	15-21	33	32	0	1	0.02	0.12	1.97	2.98
	22-28	37	35	0	0	0.00	0.03	1.97	3.01
	29-4	33	36	0	0	0.03	0.08	2.00	3.09
August	5-11	41	34	0	0	0.05	0.13	2.05	3.22
	12-18	43	29	0	2	0.00	0.10	2.05	3.32
	19-25	37	30	0	3	0.00	0.16	2.05	3.48
	26-1	41	29	0	2	0.00	0.18	2.05	3.66
Septembe	2-8	27	29	28	4	0.00	0.09	2.05	3.75
	9-15	32	24	14	11	0.60	0.14	2.65	3.89
	16-22	33	24	0	12	0.00	0.19	2.65	4.08
	23-29	29	24	28	23	0.13	0.13	2.78	4.21
	30-6	31	20	57	25	0.00	0.06	2.78	4.27
October	7-13	17	18	100	40	0.09	0.17	2.87	4.44
	14-20	20	18	86	71	0.00	0.12	2.87	4.56
	21-27	12	15	86	67	0.02	0.32	2.89	4.88

Table 6. A comparison of monthly mean air temperatures and wind miles, total precipitation, and pan evaporation (EVAP) versus evapotranspiration (ET) for NOAA and AgriMet (AGM) weather stations at Klamath Experiment Station, OR, 2001.

	Air temperature										EVAP	ET
	Maximum		Minimum		Mean		Precipitation		Wind			
Month	NOAA	AGM	NOAA	AGM	NOAA	AGM	NOAA	AGM	NOAA	AGM	NOAA	AGM
	°F						in		miles/day		in	
January	42	42	17	21	30	31	0.20	0.27	71	73	---	0.84
February	43	42	20	24	31	33	0.48	0.51	112	107	---	1.31
March	55	54	25	28	40	41	0.78	0.91	103	102	---	2.84
April	54	53	25	28	40	41	0.94	1.03	115	113	---	3.93
May	75	74	36	39	55	58	0.61	0.65	112	108	9.00	8.10
June	75	73	37	40	56	58	0.23	0.22	123	119	10.27	8.79
July	84	82	43	47	64	65	0.22	0.19	104	100	11.45	9.65
August	87	86	45	48	66	68	0.05	0.05	88	87	10.69	8.72
September	79	78	36	40	57	59	0.73	0.62	70	70	7.13	5.36
October	68	66	27	32	48	49	0.33	0.31	75	77	---	3.27
November	49	48	24	26	36	37	2.88	2.49	90	95	---	1.19
December	37	36	21	23	29	29	2.58	2.46	99	96	---	0.50
Mean	62	61	30	33	46	47			97	96		
Total[1]							10.03	9.71			48.54	40.62

[1] Total from May 1 through September 30 for the AGM ET.

Table 7. A comparison of monthly mean air temperatures and total monthly precipitation at the AgriMet weather stations located at the Klamath Experiment Station (KES), Lower Klamath Lake (LKL), Agency Lake Ranch (ALR), and Langell Valley (LV), OR, 2001.

	Air temperature												Precipitation			
	Maximum				Minimum				Mean							
Month	KES	LKL	ALR	LV	KES	LKL	ALR	LV	KES	LKL	ALR	LV	KES	LKL	ALR	LV
	°F												in			
January	42	42	39	-	21	19	18	-	31	31	28	-	0.27	0.20	0.41	-
February	42	43	41	-	24	23	23	-	32	32	32	-	0.51	0.35	0.52	-
March	54	54	52	-	28	28	32	-	41	42	42	-	0.91	0.84	1.06	-
April	53	54	50	53	28	28	32	26	41	41	42	40	1.03	1.06	0.44	0.95
May	74	74	71	75	39	35	41	36	58	57	56	57	0.65	0.36	0.52	0.51
June	73	74	69	75	40	35	41	38	58	57	56	58	0.22	0.16	0.07	0.40
July	82	83	79	83	47	41	45	44	66	64	63	65	0.19	0.11	0.83	0.94
August	86	87	83	87	48	43	44	45	68	66	64	67	0.05	0.24	0.02	0.23
September	78	77	76	78	40	35	36	37	59	56	56	58	0.62	0.57	0.67	0.95
October	66	67	64	67	32	26	29	28	49	46	46	47	0.31	0.27	0.91	0.43
November	48	49	46	50	26	23	26	24	37	35	36	36	2.49	2.02	3.07	2.39
December	36	37	37	39	23	23	22	24	31	31	30	32	2.46	1.92	3.96	1.98
Mean	61	62	59	IN[1]	33	30	32	IN[1]	48	47	46	IN[1]				
Total													9.71	8.10	12.48	(8.78)[1]

[1] Datum incomplete.

Potato Variety Screening

Kenneth A. Rykbost and Brian A. Charlton[1]

Abstract

The Oregon potato variety development program released Wallowa Russet, a dual-purpose, long russet selection in 2001. This high-yielding line, tested as AO87277-6, has excellent processing quality for French fry production and is less susceptible to tuber infection by late blight (*Phytophthora infestans*) than Russet Burbank. Two additional selections will be released as soon as adequate seed supplies become available. These include Willamette, an oval white-skinned chipping variety that produces good chip color out of cool storage. This selection, tested as AO91812-1, is medium-late maturing, produces high yields of medium-size tubers, and has low susceptibility to early blight (*Alternaria solani*) and net necrosis caused by potato leaf roll virus. The red-skinned selection, NDO4300-1R, is planned for release as Modoc. This early maturing, bright-colored selection produces intermediate yields with relatively small tuber size and few internal and external defects.

The Oregon program also participated in the development of a 2001 release from the Idaho program. Ivory Crisp was originally selected by the Oregon program. This round white chipping selection produces good chip color when processed from cool storage. It was discarded from the Oregon program for shatter bruise susceptibility. Commercial interest from eastern Idaho growers convinced the Idaho variety development program to pursue release.

The Klamath Experiment Station (KES) serves as a short-season trial site for screening of breeding lines after the second year of field production. In 2001, KES trials evaluated 95 selections in the preliminary yield trial, 20 entries in the statewide trial, and 18 selections in the western regional trial. The trials were conducted at a site 25 miles east of KES where well water was available for irrigation.

Introduction

The Oregon potato variety development program produces about 65,000 seedling tubers annually in greenhouse culture from true seed produced at the USDA Agricultural Research Service potato breeding program at Aberdeen, Idaho. About 10,000 seedling tubers are also produced from Oregon State University's Department of Crop and Soil Science (CSS) crosses focusing on viral disease resistance.

First generation field screening of material derived from the Idaho breeding program is conducted at the Central

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Oregon Agricultural Research Center (COARC). Several hundred clones are typically retained annually for further evaluation. Selections saved are grown at COARC in 12-hill plots and at the Hermiston Agricultural Research and Extension Center (HAREC) in 4-hill plots in the second year. Seed increase of surviving clones for further evaluation is derived from the COARC plots.

Breeding lines produced at CSS are grown under high disease pressure at HAREC in first generation field screening. Lines exhibiting resistance to potato virus Y (PVY), potato leaf roll virus (PLRV), and/or *verticillium* wilt are increased at COARC in the second field generation. Third-year field screening in preliminary yield trials is conducted at Malheur Experiment Station (MES), KES, COARC, and HAREC. Superior lines are advanced to Oregon statewide trials conducted at the above sites.

Following 2 or 3 years of evaluation in statewide trials, promising selections are advanced to tri-state (Oregon, Washington, and Idaho) and western regional trials where evaluations are expanded to include more detailed analysis of culinary quality, disease reactions, chemical composition, and response to storage conditions. The formal screening process requires approximately 10 years from the breeding cross to graduation from 3 years of evaluation in western regional trials. The naming and release of superior clones is usually delayed for 2-3 years after formal evaluations are completed to build seed supplies and gain commercial experience.

Evaluation procedures followed in the development process lead to characterization of over 50 attributes describing plants, tubers, yield, disease reactions, culinary quality, and physiological responses to stress. Selections that survive the entire process are exposed to a wide range of soil types, weather and climatic conditions, cultural management practices, and disease and stress conditions at about 20 locations in seven western states. Some of the selections are also included in trials in other regions including the midwest, southeast, and/or northeast.

This report summarizes the performance of entries in preliminary yield, statewide, western regional, and red-skinned/yellow-fleshed trials conducted by KES in 2001. Greater details on performance of advanced selections over years and at other locations can be obtained through the fully interactive database maintained at COARC's web page at www.css.orst.edu/coarc/database.htm.

Procedures

All trials were conducted on Fordney loamy fine sand at the U.S. Timberlands Tree Nursery in Yonna Valley approximately 25 miles east of Klamath Falls. The field was used for coniferous tree seedling production in 1999 and 2000. The site was treated with methyl bromide at 235 gal/acre and chloropicrin at 115 gal/acre in the spring of 1999. The soil has approximately 1.0 percent organic matter in the plow layer and a pH of about 7.0.

Seed for all trials was hand-cut to approximately 1.5-2.5 oz/seedpiece on May 10 and 11. All seed was treated with Tops MZ® (thiophanate methyl-mancozeb, Gustafson) at 1.0 lb/cwt, and suberized at about 55°F and >90 percent relative humidity. Potatoes were planted at 9-in spacing in 32-in rows with a two-row, assisted feed planter on May 24 and 25. Fertilizer was banded on both sides of rows at planting at 160 lb N/acre, 80 lb P_2O_5/acre, 80 lb K_2O/acre, and 140 lb S/acre. Irrigation was applied with solid-set Nelson rotator sprinklers arranged on a 30- by 40-ft spacing. Total crop water, including precipitation and irrigation, was approximately 20 in.

No herbicides were applied to the field in 2001. Soil fumigation used for the preceding crop provided satisfactory weed control. The fungicides Dithane® (mancozeb, Room and Haas) and Quadris® (Azoxystrobin, Zeneca Ag Products) were applied aerially at labeled rates during July and August. Vines were desiccated with Diquat (diquat dibromide, Seneca) applied with a conventional ground sprayer at 1.5 pt/acre on September 7 and shredded with a rotobeater 1 day before harvest.

All trials were arranged in a randomized complete block design. The preliminary yield trial included two replications of 20-hill plots. Statewide, western regional, and red-skinned/yellow-fleshed trials included four replications of 30-hill plots. The preliminary yield trial included standard varieties Russet Burbank, Shepody, Ranger Russet, Russet Norkotah, and Umatilla Russet, and 90 numbered selections. The statewide advanced yield trial included the same 5 standard varieties and 15 numbered selections. Western regional trial entries included standard varieties Russet Burbank, Ranger Russet, Russet Norkotah, and Klamath Russet, and 14 additional selections. A trial with red-skinned and yellow-fleshed selections included standard varieties Red LaSoda, Dark Red Norland, Yukon Gold, Mazama, and Modoc (NDO4300-1R), and 13 numbered selections.

Potatoes were harvested with a one-row, digger-bagger on September 27 (statewide and western regional trials), September 28 (preliminary yield trial), and October 1 (red-skinned and yellow-fleshed trial). All tubers from each plot were stored at approximately 55°F and 95 percent relative humidity until samples were graded during mid-October.

External tuber characteristics were noted for each replication during grading. USDA grade standards were used to differentiate grades. For red-skinned and yellow-fleshed lines, grades included U.S. No. 1s <4 oz, 4-6 oz, 6-10 oz, and >10 oz, and culls. All other trials were graded to separate B size (<4 oz); U.S. No. 1s 4-12 oz, and >12 oz; U.S. No. 2s; and culls. Subsamples of approximately 10 lb of mid-sized U.S. No. 1s were used to determine specific gravity by the weight-in-air, weight-in-water method for each plot. Ten large tubers from each plot were cut lengthwise and inspected for internal defects including hollow-heart, brown-center, vascular discoloration, and black-spot bruises. U.S. No 1 yields were not adjusted for external blemishes such as rhizoctonia or scab or internal defects such as hollow-heart or brown-center. A subsample of 8- to12-oz tubers from one replication of each selection in preliminary, statewide, and western regional trials was used for processing quality evaluations conducted in early November.

Data from the preliminary yield trial were not analyzed statistically because the trial only included two replications. Yield, specific gravity, and internal defect data from all other trials were analyzed using MSTAT (Microcomputer Statistical Program, Michigan State University) software. Least significant differences (LSD) are based on Student's t at the 5 percent probability level. Only a portion of the data collected is reported here. Data from trials at all locations were compiled and reviewed by all cooperators as the basis for decisions on disposition of selections evaluated.

Results and Discussion

Growing season conditions were generally favorable, resulting in relatively high yields. A mild frost (29°F) on June 13 coincided with early emergence. Irrigation was not applied to protect plants and minor injury was sustained to emerged plants as well as sprouts not yet emerged. Most plants recovered well. No further frosts were experienced at the site until mid-September. High temperatures through the tuber-bulking period resulted in some degree of physiological stress to susceptible lines. Air temperatures at KES reached or exceeded 90°F on 31 days in 2001. The incidence of growth cracks, knobs, misshapen tubers, and internal defects was greater than commonly observed in trials conducted at KES.

Poor application uniformity of the irrigation system resulted in uneven soil moisture levels in the field. Excessive soil moisture near sprinkler heads and pipe joints contributed to occurrence of pink rot (*Phytophthora erythroseptica*) in rows adjacent to sprinkler lines. Non-plot border rows were predominantly involved and few plots were affected by pink rot. Severe pink rot infections occurred in several commercial fields in the Klamath Basin in 2001. The uneven moisture conditions in these trials resulted in a significant incidence of hollow heart and/or brown center in susceptible selections and probably also contributed to external defects.

Rhizoctonia (*Rhizoctonia solani*) infections on stems and stolons, aerial tubers, and sclerotia on daughter tubers were common in some selections. Foliar early blight (*Alternaria solani*) infections were severe in some lines in late August. Silver scurf (*Helminthosporium solani*) was observed on tubers of some selections during grading. The source of pathogens causing these diseases could be attributed to seed contamination but may also be soil borne. The site of these trials was exposed to potato crops in the past decade.

Preliminary Yield Trial

Based on analysis of performance data from four locations, 12 numbered selections from the preliminary yield trial were advanced to the 2002 statewide trial for further evaluation. Russet Norkotah produced the highest yield of U.S. No. 1s among the standard varieties in the KES trial, ranking 38th out of 95 entries. Russet Burbank ranked 88th at KES. Ranger Russet, Shepody, and Umatilla Russet ranked 63rd, 74th, and 60th, respectively, in U.S. No. 1 yields at KES.

Seven of the selections retained for further testing exceeded Russet Norkotah in U.S. No. 1 yields and five of these ranked among the top eight at KES (Table 1). As frequently observed, performance of selections across locations was inconsistent in many cases. AO97175-13 produced the highest yield of U.S. No.1s at KES but ranked 12th, 28th, and 78th at COARC, HAREC, and MES, respectively. Conversely, AO97303-2 ranked 65th at KES, but 7th at MES and 14th at both COARC and HAREC.

Most of the selections advanced to the statewide trial were relatively free from external and internal defects compared with the Russet Burbank and Ranger Russet standards. All were russet types considered suitable for fresh market and/or frozen French fry production except AO97143-1, which produced an extremely high yield at HAREC (1,380 cwt/acre) and may be an excellent candidate for starch production.

Statewide Trial

All entries except AO96060-1 produced excellent stands and early season vigor (Table 2). Total yields of standard varieties were quite similar in this trial to those observed in the preliminary yield trial (Table 3). Total U.S. No. 1 yields were slightly higher for Russet Burbank and Shepody but lower for Ranger Russet, Russet Norkotah, and Umatilla Russet in the statewide trial. All entries except AO96060-1 produced higher total U.S. No. 1 yields than Russet Burbank. Only four entries produced numerically higher total U.S. No. 1 yields than Russet Norkotah and none were significantly higher than Russet Norkotah. All four of the high-yielding selections at KES were retained for further evaluation. Averaged over all locations, they ranked 1, 2, 3, and 5 in total U.S. No. 1 yield for AO96164-1, AO96160-3, AO96177-6, and AO96176-3, respectively. Each of these selections produced total U.S. No. 1 yields in excess of 600 cwt/acre in the 2000 preliminary yield trial at KES. All are considered multi-purpose russets suitable for processing or fresh market use. They will be returned to the statewide trial for at least one more year in 2002. The only other selection from the statewide trial retained for further evaluation is AO94110-203, which will be advanced to the tri-state trial in 2002. This selection is also a multi-purpose russet. Tuber shape may not be elongated enough for French fry production.

Internal defects were notably absent in most of the entries in the statewide trial. Russet Burbank was the only selection to exhibit brown center. Russet Norkotah had the highest incidence of hollow heart (Table 2). External defects were common in standard varieties and several numbered selections. Most tubers graded as U.S. No. 2s were misshapen or had shallow growth cracks. Knobs and deep growth cracks were the most common cause of cullage. Purple pigmentation was noted in the flesh of AO96177-6 and AO92017-6 during grading and in AO92017-6, AO96176-3, and AO96262-1 when seed was cut in the spring. This defect is occasionally observed in Russet Norkotah and other selections in the short-season areas at Klamath Falls and Powell Butte (COARC). It is also quite commonly observed in the San Luis Valley in Colorado. The defect does not occur in the long-season production areas of Ontario and the Columbia Basin.

Most of the entries produced relatively dark fry colors at KES (Table 2). Fry colors darker than 1.0 are generally considered unacceptable. This was not unexpected as storage temperatures were reduced to 40°F about 2 weeks before fry tests were conducted. Lighter fry colors were observed at the other trial sites.

Western Regional Trial

The 2001 western regional trial at Yonna Valley included formal entries as well as two seed lots of Klamath Russet, the fresh market russet variety released from the Oregon program in 2000. Both lots of Klamath Russet and ATX9202-3Ru experienced delayed emergence and lower final stands than the other entries in the trial (Table 4). Stand loss may have contributed to excessive tuber size and hollow heart incidence in Klamath Russet lots. As in the statewide trial, Russet Burbank tubers had a significant incidence of brown center but no hollow heart. Several of the entries had a high incidence of hollow heart. In most cases, entries with a high incidence of hollow heart in this trial also experienced similar problems in the 2001 trial at Aberdeen, Idaho. The defects were generally observed in tubers larger than 16 oz. Fry colors were dark for most entries, but particularly for Russet Norkotah, the Texas strains of Russet Norkotah, and both seed lots of Klamath Russet.

Yields and grades of standard varieties were similar to results observed in the statewide trial (Table 5). All entries except AC87079-3 and AC91014-2 produced significantly higher U.S. No. 1 yields than Russet Burbank. Performance for Klamath Russet differed between seed lots. The commercial seed lot produced significantly higher U.S. No. 1 yield with larger tuber size than the COARC seed lot. Texas strains of Russet Norkotah achieved numerically higher U.S. No. 1 yields than standard Russet Norkotah at this site and averaged over the nine late harvest regional trial sites.

Six entries completed 3 years of evaluation in the regional trials in 2001. Averaged over years and locations, the Texas strains of Russet Norkotah produced about 60 cwt/acre more U.S. No. 1 yield than standard Russet Norkotah. The Texas program is planning to release TXNS296 and discard TXNS102. A8893-1 and A9014-2 exceeded Russet Burbank in U.S. No.1 yield by about 130 and 100 cwt/acre, respectively, over years and locations. Both selections produced lighter fry color than Russet Burbank out of 45^0F storage. Commercial seed increases of both selections are ongoing. The Colorado selections AC87079-3 and AC87138-4 produced average No. 1 yields about 90 cwt/acre higher than Russet Burbank. Both selections were rated equal to or better than Russet Burbank in processing quality. A high incidence of hollow heart has been noted at several locations in both selections. Final disposition of these selections has not been determined.

Four selections from the 2001 trial will remain in trial in 2002. They include A9045-7, A90586-11, AC89536-5, and Stampede Russet, a new release from the Colorado breeding program. Three selections being discarded include AC91014-2, AO92017-6, and ATX9202-3RU. For the first time since the western regional trials were formally established, the 2002 russet trial will not include any Oregon selections.

Red-skinned and Yellow-fleshed Trial

All red-skinned and yellow-fleshed selections produced good early season vigor and excellent stands (Table 6). Mazama was rated earliest in vine maturity while NDO4323-2R, AO96747-1R, and AO96747-2R/Y were latest in maturity. Red LaSoda tubers were light colored and deep eyed as is typical for the variety in local tests. Several entries rated high for good color and shallow eyes, including Mazama and Modoc.

All selections achieved relatively high total yields (Table 7). However, in most cases, tubers larger than 10 oz accounted for a significant portion of the yield. Markets for red-skinned varieties prefer small tubers and offer premium prices for tubers under 4 oz. Based on marketable yields for U.S. No. 1s under 10 oz and a premium price for tubers under 4 oz, AO96747-2R/Y was in a class by itself. This selection has a very attractive appearance with good skin color and shallow eyes, and has flesh color similar to Yukon Gold. The selection has short dormancy and sprouts early. It will be entered in the regional specialty trial in 2002. The second highest yield of marketable tubers was achieved by AO96747-1R. This sibling to the yellow-fleshed selection was similar in maturity, but produced larger tuber size and white flesh. AO96747-1R and AO93487-2R are being advanced to the 2002 regional trial.

Among formal red-skinned entries, selections A92653-3R and A92657-1R are being discarded. NDC5281-2R and NDTX4271-5R will remain in the trial in 2002. A decision was also made to retain NDO4323-2R at the request of California. However, at most locations including Tulelake, California, this selection has experienced excessive growth cracks. TX1523-1RU/Y, a russet-skinned, yellow-fleshed selection, is also being retained for further testing. It was similar to Yukon Gold in yield, tuber size, and shape at KES. Both selections produced a high percentage of oversize tubers.

Summary

The Oregon potato variety development program has matured during the past 3 years. Releases developed from the program during this period include Umatilla Russet, Russet Legend, Klamath Russet, Wallowa Russet, Mazama, Winema, and Ivory Crisp. Umatilla Russet ranked 9th in United States acreage in 2001 and is currently being evaluated in about 15 countries for processing use. Klamath Russet and Mazama are in considerable demand in the Klamath Basin and other areas, but currently have very limited seed supplies. Wallowa Russet has good resistance to late blight tuber decay and excellent processing quality. This variety may challenge current favorites for French fry production. Willamette, soon to be released, has excellent chipping quality out of cool storage. Late maturity and a tendency for stolons to cling to tubers are its main limitations. The red-skinned Modoc produces a high yield of small, high-value tubers compared with current standards.

There is a high likelihood that several of the recent Oregon releases will enjoy significant success in the North American potato industry, including the fresh market sectors in the Klamath Basin and central California. The Oregon program initiatives have recently taken on new priorities that will take several years to produce advanced material. Disease resistance and development of materials for specialty markets will be emphasized in the current decade. The KES program will lead specialty variety screening efforts beginning in 2002.

Table 1. Tuber yield and specific gravity of potato entries selected from the Preliminary Yield Trial for further evaluation, Klamath Falls, OR, 2001.

Variety or 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	Specific gravity
	cwt/acre							
Russet Burbank	291	44	335	52	76	9	472	1.084
Ranger Russet	277	179	456	32	103	26	617	1.085
Shepody	236	181	417	14	83	67	581	1.075
Russet Norkotah	316	209	525	14	20	3	562	1.069
Umatilla Russet	318	143	461	27	117	11	615	1.082
AO96382-3	250	214	464	22	86	6	578	1.086
AO97178-1	451	230	681	11	8	0	700	1.093
AO97318-2	290	102	392	16	59	17	484	1.084
AO97133-2	382	291	673	17	68	10	768	1.082
AO97278-3	354	192	546	16	91	10	663	1.083
AO97303-2	367	80	447	52	43	0	542	1.090
AO97109-3	403	116	519	43	37	6	605	1.084
AO97118-3	481	159	640	38	25	0	703	1.080
AO97131-3	519	121	640	44	5	11	700	1.083
AO97143-1	495	24	519	121	12	0	652	1.100
AO97171-4	348	194	542	22	16	10	590	1.079
AO97175-13	463	263	726	28	41	0	795	1.084
Mean[1]	367	161	528	33	52	11	624	1.084

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

Table 2. Characteristics of potato entries in the Oregon Statewide Trial, Yonna Valley, OR, 2001.

Variety or selection	Percent stand	Vine maturity[1]	Specific gravity	Hollow heart[2]	Brown center[2]	Fry color[3]
				%	%	
Russet Burbank	98	3.6	1.090	0	20	1.00
Ranger Russet	99	3.8	1.085	0	0	1.50
Shepody	94	2.6	1.076	3	0	1.50
Russet Norkotah	98	2.9	1.072	13	0	2.00
Umatilla Russet	94	3.1	1.087	3	0	2.00
AO92017-6	91	4.5	1.092	0	0	2.00
AO94110-203	93	4.3	1.091	3	0	1.50
AO92023-3	98	2.6	1.075	3	0	1.50
AO92019-4	99	2.4	1.077	0	0	1.50
AO94004-3	99	3.0	1.088	8	0	2.00
AO96060-1	61	3.2	1.085	3	0	2.00
AO96065-7	98	4.0	1.095	8	0	2.00
AO96160-3	100	4.5	1.095	0	0	1.00
AO96164-1	96	4.1	1.085	0	0	2.00
AO96165-2	98	3.6	1.088	0	0	1.50
AO96165-9	97	2.8	1.087	0	0	2.00
AO96176-3	95	3.6	1.087	0	0	0.50
AO96177-6	98	4.4	1.092	3	0	0.00
AO96262-1	98	2.9	1.088	0	0	0.50
AO96272-1	98	3.0	1.088	0	0	1.50
Mean	95	3.4	1.086	2	1	1.5
CV (%)	-	-	0.3	201	183	-
LSD (0.05)	-	-	0.004	6	3	-

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

[2]Hollow heart and brown center in 10 large tubers/sample.

[3] Fry color: 0.00 = light, 4.0 = dark.

Table 3. Tuber yield by grade for potato entries in the Oregon Statewide Trial, Yonna Valley, OR, 2001.

Variety or	Yield U.S. No. 1s				Yield			
selection	4-8 oz	8-12 oz	>12 oz	total	Bs	No. 2s	culls	total
	cwt/acre							
Russet Burbank	182	119	50	351	49	55	55	510
Ranger Russet	141	122	150	413	12	85	37	547
Shepody	123	133	191	447	23	58	8	536
Russet Norkotah	123	146	212	481	23	40	11	555
Umatilla Russet	140	130	120	390	26	82	35	533
AO92017-6	130	129	176	435	27	77	41	580
AO94110-203	193	128	82	403	49	16	11	479
AO92023-3	141	179	145	465	27	29	7	528
AO92019-4	157	136	118	411	23	6	5	445
AO94004-3	151	168	125	444	29	17	27	517
AO96060-1	193	116	32	341	47	20	10	418
AO96065-7	194	155	58	407	39	46	15	507
AO96160-3	265	171	77	513	54	9	1	577
AO96164-1	207	180	121	508	31	18	19	576
AO96165-2	219	141	93	453	51	16	8	528
AO96165-9	224	134	42	400	52	9	34	495
AO96176-3	152	182	223	557	22	32	21	632
AO96177-6	68	85	340	493	7	57	15	572
AO96262-1	153	140	88	381	31	39	28	479
AO96272-1	201	124	82	407	40	102	33	582
Mean	168	141	126	435	33	41	21	530
CV (%)	16	22	35	13	25	47	90	10
LSD (0.05)	38	44	63	79	12	27	NS	72

Table 4. Characteristics of potato entries in the Western Regional Trial, Yonna Valley, OR, 2001.

Variety or selection	Percent stand	Vine maturity[1]	Specific gravity	Hollow heart[2]	Brown center[2]	Fry color[3]
				%	%	%
Russet Burbank	98	3.6	1.085	0	18	1.0
Ranger Russet	98	3.8	1.088	0	0	1.5
Russet Norkotah	96	2.8	1.072	10	0	4.0
Klamath Russet[4]	88	5.0	1.079	8	3	3.0
A8893-1	96	3.1	1.081	25	5	0.0
A9014-2	94	3.3	1.081	13	0	1.5
A9045-7	96	4.6	1.086	0	0	2.0
A90586-11	98	4.5	1.089	0	0	1.0
AC87079-3	95	3.0	1.088	70	0	2.0
AC87138-4	94	4.3	1.085	55	0	1.0
AC89536-5	98	3.5	1.089	5	8	2.0
AC91014-2	98	2.9	1.092	35	0	1.0
AO92017-6	93	4.0	1.087	0	0	1.5
ATX9202-3Ru	88	4.5	1.083	0	0	0.0
Stampede Russet	97	3.6	1.070	0	0	1.0
TXNS102	99	3.0	1.075	18	0	4.0
TXNS296	99	2.6	1.074	8	0	3.5
Klamath Russet[5]	89	5.0	1.083	13	0	4.0
Mean	95	3.7	1.083	14	2	2
CV (%)	-	-	0.3	78	313	-
LSD (0.05)	-	-	0.005	16	8	-

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

[2]Hollow heart and brown center in 10 large tubers/sample.

[3] Fry color: 0.00 = light, 4.0 = dark.

[4] Seed source -- Central Oregon Agricultural Research Center.

[5] Seed source -- commercial grower.

Table 5. Tuber yield by grade for potato entries in the Western Regional Trial, Yonna Valley, OR, 2001.

Variety or selection	Yield U.S. No. 1s 4-8 oz	8-12 oz	>12 oz	total	Yield Bs	No. 2s	culls	total
	cwt/acre							
Russet Burbank	153	118	57	328	58	57	65	508
Ranger Russet	120	135	179	434	26	88	47	595
Russet Norkotah	103	110	225	438	16	44	27	525
Klamath Russet[1]	127	104	202	433	27	66	26	552
A8893-1	162	174	187	523	23	58	8	612
A9014-2	138	132	166	436	25	41	14	516
A9045-7	98	140	271	509	9	47	18	583
A90586-11	148	148	206	502	32	78	27	639
AC87079-3	141	145	103	389	44	30	20	483
AC87138-4	122	137	237	496	29	67	35	627
AC89536-5	170	128	107	405	41	31	25	502
AC91014-2	191	119	37	347	65	19	5	436
AO92017-6	182	140	149	471	42	47	8	568
ATX9202-3Ru	138	181	260	579	18	37	2	636
Stampede Russet	155	158	241	554	24	29	12	619
TXNS102	116	124	235	475	24	63	17	579
TXNS296	128	129	243	500	33	51	24	608
Klamath Russet[2]	122	119	275	516	17	76	14	623
Mean	140	136	188	463	31	52	22	567
CV (%)	18	23	23	11	40	37	82	9
LSD (0.05)	36	43	62	75	17	27	25	72

[1] Seed source -- Central Oregon Agricultural Research Center.

[2] Seed source -- commercial grower.

Table 6. Plant and tuber characteristics of advanced red-skinned and yellow-fleshed potato selections grown at Yonna Valley, OR, 2001.

Variety or selection	Percent stand	Vine vigor[1]	Vine maturity[2]	Tuber characteristics[3] color	eyes	shape
Dk. Red Norland	98	4.8	2.8	3.3	1.8	2.0
Red LaSoda	93	3.8	3.3	2.0	1.0	2.0
Yukon Gold	96	3.8	3.1	Yellow	3.5	2.0
A92653-6R	96	4.0	3.1	3.0	4.0	1.0
A92657-1R	96	3.3	3.6	4.5	4.0	1.5
NDC5281-2R	99	4.0	2.4	4.0	4.8	1.0
NDO4323-2R	98	2.5	3.9	4.0	2.8	1.5
NDTX4271-5R	93	3.3	3.5	4.0	4.0	1.0
TX1523-1RU/Y	98	3.8	3.0	Lt. Russ	3.5	1.9
AO91852-1R	98	3.5	2.8	5.0	4.0	1.5
AO91854-1R	100	2.8	3.1	5.0	3.3	1.5
AO93487-2R	99	3.8	2.0	4.8	4.0	1.4
AO96747-1R	98	4.5	3.9	5.0	3.0	1.0
AO96747-2R	98	4.0	3.8	4.5	4.0	1.1
AO96751-1R	98	3.5	3.1	4.0	3.0	1.6
NDO7130-1R	96	4.5	2.6	4.8	3.8	1.9
Mazama	96	4.5	1.9	5.0	5.0	1.4
Modoc	93	3.0	2.4	5.0	4.0	1.5
Mean	97	3.7	3.0	4.2	3.5	1.5

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

[2]Vine maturity: 1 is early, to 5 for a late-maturing plant.

[3]Color: 1 is pale to pink, to 5 for bright red.

Eye depth: 1 is deep, to 5 for shallow.

Shape: 1 is round, 2 for oval, 3 for oblong.

Table 7. Yield, grade, tuber size distribution, and specific gravity of advanced red-skinned and yellow potato selections grown at Yonna Valley, OR, 2001.

Variety or	Yield U.S. No. 1s					Yield		
selection	<4 oz	4-6 oz	6-10 oz	>10 oz	total	marketable[1]	culls	total
	cwt/acre							
Dk. Red Norland	33	114	219	251	617	366	40	657
Red LaSoda	14	48	112	311	485	174	127	612
Yukon Gold	22	72	155	287	536	249	29	565
A92653-6R	66	174	239	87	566	479	28	594
A92657-1R	17	84	150	330	581	251	51	632
NDC5281-2R	98	199	156	42	495	453	22	517
NDO4323-2R	50	114	189	174	527	353	54	581
NDTX4271-5R	55	136	247	131	569	438	26	595
TX1523-1RU/Y	27	95	138	234	494	260	16	510
AO91852-1R	30	99	221	340	690	350	8	698
AO91854-1R	43	148	212	135	538	403	23	561
AO93487-2R	41	124	180	198	543	345	7	550
AO96747-1R	63	191	261	130	645	515	34	679
AO96747-2R	149	228	159	44	580	536	8	588
AO96751-1R	39	134	210	190	573	383	34	607
NDO7130-1R	79	189	181	67	516	449	40	556
Mazama	49	168	201	161	579	418	9	588
Modoc	43	166	241	130	580	450	19	599
Mean	51	138	193	180	562	382	32	594
CV (%)	31	22	20	27	10	12	65	8
LSD (0.05)	23	43	41	70	76	64	30	67

[1]Marketable: <4 oz to 10 oz U.S. No. 1s.

Evaluation of Seed Aging to Enhance Performance of New Russet Potato Varieties

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Abstract

The newly released potato varieties, Klamath Russet and Gem Russet, have appearance and culinary quality characteristics that make them good candidates for production as fresh market varieties in the Klamath Basin. Yield tests conducted locally have demonstrated that these cultivars are as high as or higher yielding than Russet Burbank with greatly improved tuber shape and size distribution. However, both varieties are moderately late in vine maturity and exhibit delayed plant emergence compared to Russet Burbank. These are potentially serious limitations in the Klamath Basin given the area's relatively short growing season. Field studies were conducted the past 2 years to determine if physiologically aged seed tubers would hasten emergence and improve yields of these varieties. Findings in both years demonstrated that warming the seed hastened emergence and slightly increased stem numbers, but did not significantly enhance yield in either variety.

Introduction

Physiological aging of seed can be accomplished by increasing temperature of seed tubers in storage. Physiologically aging by warming has been successfully used in other potato varieties to increase stem numbers and tuber set and to hasten plant emergence. This approach was tested on Klamath Russet, Gem Russet, and Russet Burbank varieties in paired field studies conducted at the University of California Intermountain Research and Extension Center (IREC) in Tulelake, California (2000 and 2001), at the Oregon State University Klamath Experiment Station (KES) in Klamath Falls, Oregon in 2000, and in Yonna Valley, east of Klamath Falls, Oregon in 2001.

In experiments conducted in 2000, seed tubers of the three varieties were exposed to the five storage and handling regimes as follows:

1. Removed from 40°F storage, 2 days at 50°F, cut, 2 days at 50°F, plant (Control);
2. Removed from 40°F storage, 2 days at 50°F, cut, 12 days at 50°F, plant (+140 DD);
3. Removed from 40°F storage, 12 days at 50°F, cut, 2 days at 50°F, plant (+140 DD);
4. Removed from 40°F storage, 2 days at 60°F, cut, 12 days at 60°F, plant (+280 DD);

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5. Removed from 40°F storage, 12 days at 60°F, cut, 2 days at 60°F, plant (+280 DD).

Treatments 2 and 3 resulted in physiological aging equivalent to 140 degree days (DD) above a 40°F baseline relative to the control treatment (treatment 1). For treatments 4 and 5, the physiological aging was the equivalent of 280 additional DD relative to the control.

The 2000 trial results indicated that warming the seed hastened plant emergence in Gem Russet and Klamath Russet but had little or no affect on yield. Slightly higher stem numbers were observed for warmed seed and pre-cut treatments of Klamath Russet; however, the only yield effect across all varieties was a slight increase in the yield of 4- to 8-oz tubers with early cut tubers aged at 60°F (treatment 5). In general, data suggested that pre-cutting seed 2 weeks before planting may have been more effective in increasing stem numbers than the warming treatments imposed.

Given the relative lack of yield response to physiological aging in the 2000 field studies, the experiments were repeated in 2001, with treatments employing significantly increased aging of the seed.

Procedures

Seed lots of Gem Russet, Klamath Russet, and Russet Burbank varieties were transferred from 40°F storage to small controlled-environment storage bins at IREC on March 1, 2001. Quantities of each variety were immediately transferred into separate chambers and subjected to the following treatments:

1. Maintained for 30 days at 70°F, then returned to 40°F storage (+900 DD);
2. Maintained for 20 days at 70°F, then returned to 40°F storage (+600 DD);
3. Maintained for 10 days at 70°F, then returned to 40°F storage (+300 DD);
4. Maintained for 10 days at 70°F, then 10 days at 40°F, then 10 days at 70°F, then returned to 40°F storage (+600 DD);
5. Maintained at 40°F storage (Control).

Treatment 1 resulted in physiological aging of seed equivalent to 900 DD above the base of 40°F relative to the control (treatment 5). Treatments 2 and 4 aged the seed 600 DD, while treatment 3 aged the seed an additional 300 DD relative to the control. Humidity was maintained at 95 percent during all storage treatments and all subsequent seed storage.

On May 3, 2001, seed tubers from all storage treatments were removed from the 40°F storage; warmed to 50°F, and hand-cut into approximately 1.5- to 2.0-oz seed pieces. The cut seed for IREC was then placed back into 50°F storage to suberize. The seed for Yonna Valley was placed back into 40°F storage.

The IREC seed was removed from storage and planted on May 9. Treated seed was planted into 2-row, 40-ft-long plots with 36-in row spacing and 12-in seed spacing within rows. Plots were arranged in a randomized complete block design with four replications.

Yonna Valley seed was removed from 40°F storage on May 22. Planting was accomplished on May 24. Treated seed was planted into 2-row, 30-ft plots with 32-in row spacing and 12-in seed spacing within rows. Plots were arranged in a split-plot design with varieties assigned to main plot and storage treatments to split-plots. Plots were replicated four times.

Plantings at both sites were grown to maturity using standard commercial cultural practices, fertilizer rates, irrigation, and pest management techniques. Data were collected on emergence dates, stems per plant, and tuber yield and grade. Plots were harvested at Yonna Valley on September 24 and at IREC on October 4. Tubers harvested from each plot were electronically sorted to size (weight) and grade at IREC on October 8 and 9.

Results

Rate of seedling emergence was evaluated at both locations (Tables 1 and 2). The aged seed treatments resulted in earlier emergence than control treatments for all varieties at both locations. The emergence time was shortened in Gem Russet and Klamath Russet with each incremental increase in physiological aging (Fig. 1). In contrast, Russet Burbank experienced a large response to slight aging but little incremental improvement with further aging increases. Even with significant responses to warming treatments, Klamath Russet and Gem Russet still emerged more slowly than the Russet Burbank control treatment. Gem Russet emerged more slowly than Klamath Russet. This is consistent with observations over several years in KES variety trials.

There was a significant trend for increased numbers of stems per plant with increased aging (Tables 1 and 2). Klamath Russet was significantly lower in specific gravity than Gem Russet and Russet Burbank. Aging treatments did not affect specific gravity of any variety at Yonna Valley. Relatively large differences in specific gravity between aging treatments for Klamath Russet at IREC appear to be an anomaly.

Significant yield differences were measured between varieties at both locations; however, affects of seed aging treatments on yields were not significant for any variety or location (Tables 3, 4, and 5). Results indicated an unusually high yield of off-grade tubers in Klamath Russet at both locations. At the Yonna Valley site this was due to a relatively high incidence of pink rot in several plots that were immediately adjacent to sprinkler heads. As noted elsewhere in this report, pink rot was a significant problem near irrigation pipe joints and sprinkler heads in this field. For the IREC site, off-grades in Klamath Russet were generally associated with excessive tuber size. A higher plant population than that used in this study is required to avoid excessive size in Klamath Russet.

Summary

Two years of trials at three Klamath Basin locations have confirmed the ability of Klamath Russet and Gem Russet potato varieties to produce higher marketable yields than Russet Burbank. Both new varieties produce suitable appearance for fresh market use. Aging of seed by warming in storage demonstrated small advantages to emergence timing and stem numbers, but no significant affect on total or marketable yield for either variety. Tuber size distribution data in 2001 trials clearly indicate the need for higher plant populations for Klamath Russet than either Russet Burbank or Gem Russet.

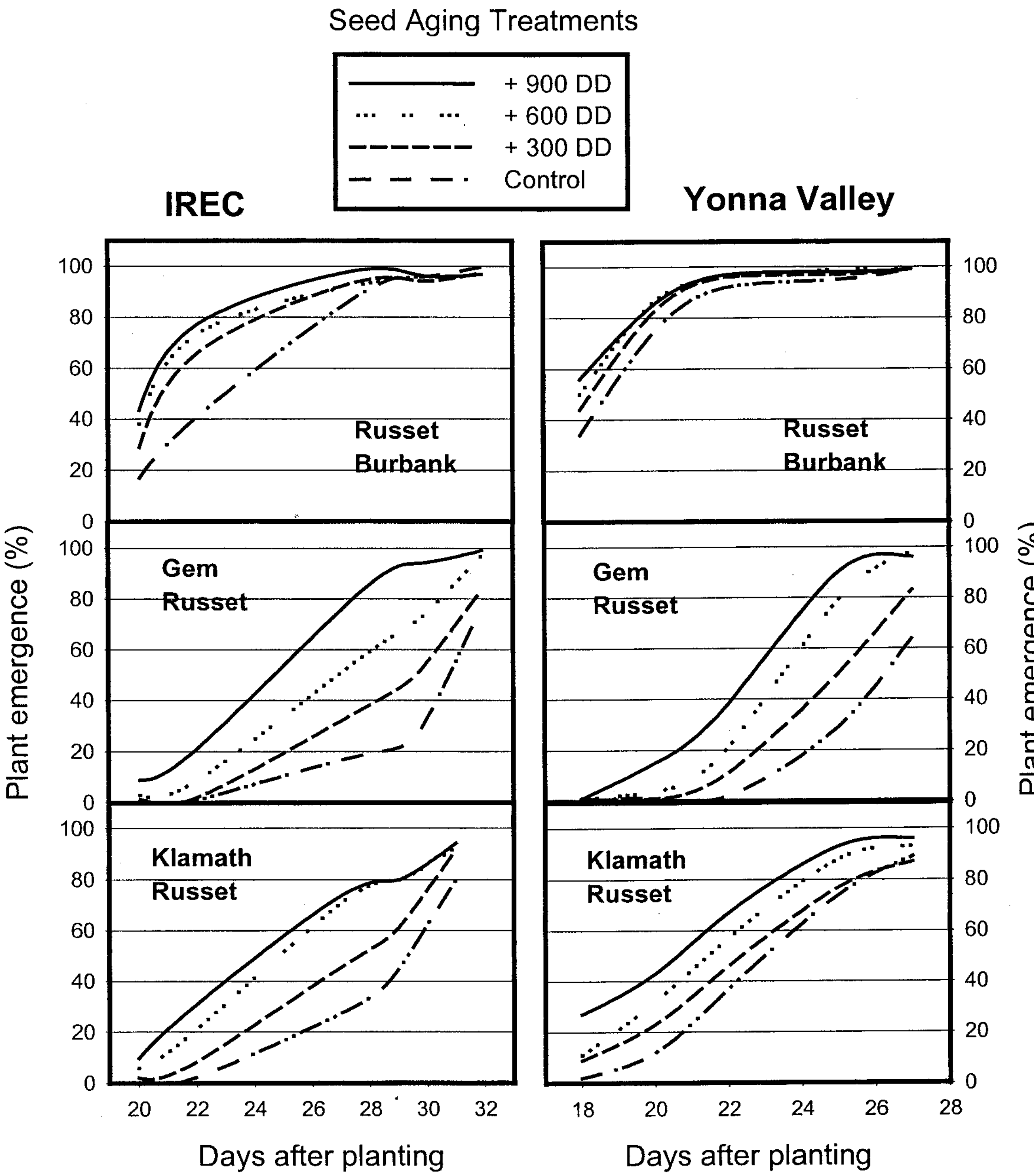

Figure 1. Affect of seed aging treatments on the plant emergence of three potato varieties at two locations in 2001

Table 1. Effect of seed conditioning on emergence, stem counts, and tuber quality of Russet Burbank, Gem Russet, and Klamath Russet grown at Yonna Valley, OR, 2001.

Variety	Trt.[1]	Emergence %					Stem number	Spec.
		18 DAP[2]	20 DAP	22 DAP	25 DAP	27 DAP	7/2	grav.
Russet Burbank	1	56	85	97	98	99	2.3	1.091
	2	50	86	96	99	99	2.3	1.090
	3	44	82	96	97	99	2.0	1.091
	4	59	85	97	98	99	1.8	1.088
	5	34	74	92	95	99	1.8	1.087
Gem Russet	1	1	15	38	90	96	2.6	1.087
	2	1	4	21	79	98	2.3	1.091
	3	1	1	11	50	83	2.0	1.092
	4	1	7	23	73	91	2.4	1.091
	5	0	1	2	29	64	2.0	1.091
Klamath Russet	1	27	43	67	93	96	3.0	1.085
	2	11	32	57	88	93	2.9	1.084
	3	9	23	46	77	87	2.8	1.083
	4	21	40	69	90	94	2.7	1.083
	5	2	12	37	74	89	2.6	1.084
Variety main effect:								
Russet Burbank		48	82	95	97	99	2.0	1.089
Gem Russet		0	5	19	64	87	2.2	1.090
Klamath Russet		14	30	55	84	92	2.8	1.084
LSD (0.05)		16	12	10	9	6	0.2	0.002
Seed conditioning sub-plot effect:								
	1	28	48	67	94	97	2.6	1.088
	2	21	40	58	88	97	2.5	1.089
	3	18	35	51	75	90	2.3	1.088
	4	27	44	63	87	95	2.3	1.087
	5	12	29	44	66	84	2.1	1.087
LSD (0.05)		13	10	8	7	5	0.6	NS
CV (%)		55	23	13	8	5	13	0.300

[1]Treatments:

1. Maintained for 30 days at 70°F, then returned to 40°F storage (+900 DD);
2. Maintained for 20 days at 70°F, then returned to 40°F storage (+600 DD);
3. Maintained for 10 days at 70°F, then returned to 40°F storage (+300 DD);
4. Maintained for 10 days at 70°F, 10 days at 40°F, 10 days at 70°F, returned to 40°F storage (+600 DD);
5. Maintained at 40°F storage (control).

[2]DAP = days after planting

Table 2. Effect of seed conditioning on emergence, stem counts, and tuber quality of Russet Burbank, Gem Russet, and Klamath Russet grown at Tulelake, CA 2001.

Variety	Trt.[1]	Emergence %					Stem number	Spec.
		20 DAP[2]	22 DAP	27 DAP	29 DAP	33 DAP	7/2	grav.
Russet Burbank	1	44	78	98	96	97	2.5	1.080
	2	38	74	93	96	96	2.8	1.081
	3	29	67	94	94	97	2.3	1.081
	4	33	82	96	97	98	2.5	1.077
	5	17	43	88	96	100	2.6	1.081
Gem Russet	1	9	23	82	94	99	2.1	1.076
	2	3	10	56	72	97	2.0	1.081
	3	1	3	36	52	83	1.8	1.081
	4	1	13	59	71	92	1.9	1.075
	5	1	2	18	28	77	1.9	1.080
Klamath Russet	1	10	31	74	80	94	2.6	1.069
	2	6	21	71	80	93	2.2	1.068
	3	2	8	45	61	92	2.1	1.078
	4	7	24	75	82	92	2.3	1.074
	5	0	2	27	45	80	2.0	1.071
Variety effect:								
Russet Burbank		32	69	94	96	98	2.6	1.080
Gem Russet		3	10	50	63	90	1.9	1.079
Klamath Russet		5	17	59	70	90	2.2	1.072
LSD (0.05)		12	14	13	12	9	NS	0.010
Seed conditioning effect:								
	1	21	44	85	90	97	2.4	1.075
	2	16	35	73	83	95	2.4	1.077
	3	11	26	58	69	91	2.1	1.080
	4	14	40	77	84	94	2.3	1.075
	5	6	15	45	56	85	2.1	1.077
LSD (0.05)		10	12	11	10	8	NS	NS
CV (%)		67	32	14	12	7	16	0.700

[1]Treatments:

1. Maintained for 30 days at 70°F, then returned to 40°F storage (+900 DD);
2. Maintained for 20 days at 70°F, then returned to 40°F storage (+600 DD);
3. Maintained for 10 days at 70°F, then returned to 40°F storage (+300 DD);
4. Maintained for 10 days at 70°F, 10 days at 40°F, 10 days at 70°F, returned to 40°F storage (+600 DD);
5. Maintained at 40°F storage (control).

[2]DAP = days after planting

Table 3. Effect of seed conditioning on yield, grade, and tuber size distribution of Russet Burbank, Gem Russet, and Klamath Russet grown at Yonna Valley, OR, 2001.

Variety	Trt.[1]	Yield U.S. No. 1s				Yield		
		4-8 oz	8-12 oz	>12 oz	Total	<4 oz	culls	Total
		cwt/acre						
Russet Burbank	1	260	166	84	510	74	71	655
	2	229	184	81	494	67	70	631
	3	250	148	61	459	78	104	641
	4	255	160	94	509	61	89	659
	5	211	159	102	472	55	107	634
Gem Russet	1	202	204	115	521	31	32	584
	2	263	212	81	556	38	23	617
	3	259	178	81	518	49	30	597
	4	239	202	80	521	37	33	591
	5	263	138	61	462	58	22	542
Klamath Russet	1	101	143	263	507	23	154	684
	2	117	155	328	600	23	116	739
	3	106	158	270	534	19	134	687
	4	107	151	288	546	19	162	727
	5	115	141	277	533	20	129	682
Variety main effect:								
Russet Burbank		241	164	84	489	67	88	644
Gem Russet		245	187	83	515	43	28	586
Klamath Russet		109	150	285	544	21	139	704
LSD (0.05)		20	22	37	NS	8	47	31
Seed conditioning main effect:								
	1	188	171	154	513	43	85	641
	2	203	184	163	550	43	69	662
	3	205	162	137	504	48	89	641
	4	201	171	154	526	39	94	659
	5	196	146	147	489	44	86	619
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS
CV (%)		16	20	38	19	27	86	8

[1]Treatments:

1. Maintained for 30 days at 70°F, then returned to 40°F storage (+900 DD);
2. Maintained for 20 days at 70°F, then returned to 40°F storage (+600 DD);
3. Maintained for 10 days at 70°F, then returned to 40°F storage (+300 DD);
4. Maintained for 10 days at 70°F, 10 days at 40°F, 10 days at 70°F, returned to 40°F storage (+600 DD)
5. Maintained at 40°F storage (control).

Table 4. Effect of seed conditioning on yield, grade, and tuber size distribution of Russet Burbank, Gem Russet, and Klamath Russet grown at Tulelake, CA, 2001.

		Yield U.S. No. 1s				Yield		
Variety	Trt.[1]	4-8 oz	8-12 oz	>12 oz	Total	<4 oz	culls	Total
					cwt/acre			
Russet Burbank	1	135	146	112	393	35	51	479
	2	111	132	88	331	36	79	446
	3	122	133	107	362	30	85	477
	4	123	127	103	353	33	84	470
	5	126	144	106	376	26	87	489
Gem Russet	1	111	138	208	457	20	26	503
	2	114	160	190	464	23	23	510
	3	114	167	158	439	23	17	479
	4	90	152	223	465	22	29	516
	5	116	138	185	439	24	23	486
Klamath Russet	1	58	99	269	426	16	95	537
	2	57	96	284	437	13	111	561
	3	64	92	288	444	15	94	553
	4	68	105	273	446	14	103	563
	5	55	113	278	446	14	82	542
Variety main effect:								
Russet Burbank		124	137	103	364	32	77	473
Gem Russet		109	151	193	453	22	24	499
Klamath Russet		61	101	279	441	15	97	553
LSD (0.05)		11	14	14	22	3	22	19
Seed conditioning main effect:								
	1	102	128	196	426	24	57	507
	2	94	129	187	410	24	71	505
	3	100	131	184	415	23	65	503
	4	94	128	200	422	23	72	517
	5	99	132	190	421	22	64	507
LSD (0.05)		NS	NS	NS	NS	NS	NS	NS
CV (%)		18	17	11	8	21	31	6

[1]Treatments:

1. Maintained for 30 days at 70°F then returned to 40°F storage (+900 DD);
2. Maintained for 20 days at 70°F, then returned to 40°F storage (+600 DD);
3. Maintained for 10 days at 70°F, then returned to 40°F storage (+300 DD);
4. Maintained for 10 days at 70°F, 10 days at 40°F, 10 days at 70°F, returned to 40°F storage (+600 DD);
5. Maintained at 40°F storage (control).

Table 5. Effect of seed conditioning on yield, grade, and tuber size distribution of Russet Burbank, Gem Russet, and Klamath Russet grown at Yonna Valley, OR, and Tulelake, CA, 2001.

Variety	Yield U.S. No. 1s				Yield		
	4-8 oz	8-12 oz	>12 oz	Total	<4 oz	culls	Total
	cwt/acre						
Location main effect:							
KES	199	167	151	516	44	85	645
IREC	97	130	192	419	23	66	507
LSD (0.05)	9	10	16	26	3	NS	15
Variety main effect:							
Russet Burbank	94	150	94	426	50	83	558
Gem Russet	177	170	138	484	33	26	542
Klamath Russet	85	126	282	492	18	118	628
LSD (0.05)	11	13	19	32	4	24	18
Seed conditioning main effect:							
1	145	149	175	469	24	71	573
2	148	157	175	480	24	70	584
3	153	146	161	460	23	77	572
4	147	150	177	474	23	83	588
5	148	139	168	455	22	75	563
LSD (0.05)	NS	NS	NS	NS	NS	NS	NS
CV (%)	17	19	25	16	27	71	7

[1]Treatments:

1. Maintained for 30 days at 70°F, then returned to 40°F storage (+900 DD);
2. Maintained for 20 days at 70°F, then returned to 40°F storage (+600 DD);
3. Maintained for 10 days at 70°F, then returned to 40°F storage (+300 DD);
4. Maintained 10 days at 70°F, 10 days at 40°F, 10 days at 70°F, returned to 40°F storage (+600 DD);
5. Maintained at 40°F storage (control).

Fiber and Oilseed Flax Performance

Brian A. Charlton[1] and Daryl Ehrensing[2]

Abstract

Two market classes of flax (*Linum usitatissimum*) were planted in an observational trial at the U.S. Timberlands Tree Nursery, Yonna Valley, Oregon in 2001 to determine whether this crop could be grown to maturity in the cool, short-season climate of the Klamath Basin. Both fiber and oilseed market classes were evaluated. Slight differences in oilseed yield were observed for Omega and Neche, while differences in oil content were negligible. Minor differences in fiber yield were observed between Argos, Elise, and Viola, while yields of Viking were considerably lower. Although oil content was low, yields of both oilseed and fiber flax are comparable to yields observed in production areas of Canada. Newly emerged flax plants are sensitive to frost damage while older plants can withstand temperatures to 24°F.

Introduction

Flax (*Linum usitatissimum*) production dates back to ancient history. Flax remnants have been recovered from Stone Age dwellings in Switzerland and ancient Egyptians made fine linens from the fiber. Flax was probably first cultivated in areas of southern Asia and the Mediterranean. Early cultivated varieties likely originated from wild flax (*Linum angustifolium*) that readily crosses with domesticated flax (Martin *et al*, 1976). Cultivation of flax began in America during the colonial period and moved westward across the northern United States and Canada during the 1800's. Demand for flax products increased during World War I and II. Flax oil and fiber were used for industrial and textile purposes, respectively. During this time, the Willamette Valley of Oregon was a major supplier of high-quality flax fiber. Development of synthetic fibers during the early 1960's reduced demand for flax fiber and eventually displaced the entire industry.

The development of synthetic alternatives has displaced many traditional markets for flax products. Synthetic fibers and petrochemical-based products have replaced flax in both textile and industrial uses. Consumer demand for biodegradable and environment-safe products is leading to a resurgence of flax usage.

Seeds from flax are crushed to produce linseed oil and linseed meal. Linseed oil is a major ingredient in many fine paints, varnishes, and stains that are used to preserve, protect, and beautify wooden surfaces. Linseed oil is also used to preserve concrete surfaces by preventing damage from water and salts. Linoleum is a flooring manufactured by oxidizing linseed oil to form a thick mixture called linoleum cement. The cement is cooled and mixed with pine resin, and wood flour to form sheets on jute backings. Linoleum is often used to describe many types of flooring, although most products are actually

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derived from polyvinyl chloride components. Vintage linoleum is making a major comeback because it is completely biodegradable, environmentally safe, non-allergenic, and very durable.

Linseed oil used for industrial purposes has approximately 50 percent linolenic acid. Industrial linseed oil turns rancid quickly and is not well suited for human consumption. New varieties of flax have been developed which contain approximately 5 percent linolenic acid. Seeds and oil with low levels of linolenic acid are suitable for human consumption. Edible flaxseed oil contains high levels of Omega-3 fatty acids. Omega-3 fatty acids, mostly found in fish, have been shown to modify several risk factors for heart disease, strokes, and certain types of cancer by interfering with the effects of estrogen (Flax Council of Canada). Currently, consumers are using flax in their diets because of its many health benefits and pleasant flavor. The pet food and poultry industries are using flax in various feeds and rations. Poultry fed rations with flax have elevated Omega-3 fatty acid levels in egg production. As nutritional research continues to unveil health benefits associated with flax, usage in the food and feed sectors should continue to increase.

Fiber from flax is used in making high-grade paper, upholstery tow, insulating materials, rugs, yarn, linen, and other textiles. As happened with linseed oil, flax fiber in many products was replaced by cotton and other synthetic fibers. Currently, fabrics using cotton and linen blends are gaining popularity. Flax fiber is also being used to produce other fibrous products such as car-door panels, planting pots, and retaining mats. Flax fiber is being blended with certain types of plastic resins to produce automotive components. Europe produces most of the high-quality long-fiber flax used for linens, rugs, and other textiles. Canada produces most of the short-fiber flax used for paper, planting pots, and other fibrous products such as car-door panels. As new markets develop, increased demand for high-quality flax fiber will continue.

Crop options for the Klamath Basin are limited by climatic conditions, a lack of processing facilities, and distance to markets. Low commodity prices for several crops grown in the region have heightened interest in finding alternative crops that offer profit potential. Flax was chosen for evaluation because market outlets for industrial and edible flax oil may be readily accessible, variable production costs are probably similar to those for cereal crops grown in the region, and value of flax for fiber and oilseed may exceed value of cereals for feed or food uses.

Procedures

Four fiber-type and two oil-type flax varieties were planted on Fordney loamy fine sand at the U.S. Timberlands Tree Nursery in Yonna Valley, Oregon. Preceding crops at the site were coniferous tree seedlings in 1999 and 2000. The site was treated in the spring of 1999 with 235 + 115 gal/acre of methyl bromide and chloropicrin, respectively. The soil has an organic matter content of about 1.0 percent in the plow layer and a pH of about 7.0. Varieties were arranged in a randomized complete block design with four replications. Seed for both types of flax was drilled to a depth of 0.75 in using a modified Kincaid (Kincaid Equipment Manufacturing) planter on May 8.

Individual plots measured 4.5 by 20 ft, with a 4.5- by 14.5-ft area harvested. Seeding rates were 150 and 40 lb/acre and drill rows measured 6 and 18 in for fiber and oil types, respectively. All plots were fertilized with 50 lb N/acre, 63 lb P_2O_5/acre, and 41 lb S/acre banded at planting. All plots received 50 lb N/acre applied during an irrigation set on June 19.

Irrigation was applied with solid-set sprinklers arranged on a 30- by 40-ft spacing. Total crop water, including irrigation and rainfall, was approximately 16 in. Previous fumigation treatments and weed control efforts provided a relatively weed-free environment. Therefore, herbicide applications were not required. Minimal hand weeding was necessary to eliminate border weed infestations. No insecticide or fungicide applications were made. Irrigation ceased on August 6 to provide adequate time for seed and stem drying.

Poor germination occurred in the center drill-row of both oilseed types. Compaction from the planter drive-wheel may have caused this effect. Yield data was collected from an outer drill-row from each plot. Seed was harvested with a Hege (Hans-Ulrich Hege) plot combine on August 21. Seeds from each plot were cleaned to remove chaff and broken kernels using a series of screens and modified air blowers. Given small sample size and non-uniform row emergence, statistical analysis was not performed.

Plots containing fiber-type varieties were hand-pulled on August 21. Morning dew and one supplemental micro-irrigation were used to promote field retting (microbial breakdown of plant pectin, which binds fiber bundles together). Stems were partially retted when field-dry straw yield was collected on September 20. Pertinent data were analyzed using MSTAT (Michigan State University) software. Least significant differences (LSD) are based on Student's *t* at the 5 percent probability level.

Results and Discussion

Yields did not significantly differ between fiber-type varieties (Table 1). Averaged across varieties and replications, yields were relatively high. Similar performance was observed for Viola, Argos, and Elise while Viking produced the lowest yield. Scutching, the method used to process flax straw, entails mechanically bending and abrading the retted straw to separate shives (woody core of the stem) and fiber. Yield of scutched fiber was estimated to be 20 percent of field-dry straw weight (Table 1). Plant height did not significantly differ between fiber-type varieties.

Plant stands in the center row of three-row plots were not uniform for oil-type varieties, probably due to excessive compaction from the planter drive-wheel. Yield data were therefore taken from the outer drill-rows. Statistical analyses were not performed on yield data due to potential effects of poor stands in the center row. Omega produced slightly higher yields of seed and oil per acre than Neche (Table 2). Oven-dry oil content did not significantly differ between Omega and Neche (Table 2). Optimum oil content will range from 40 to 48 percent under ideal conditions. Oil content averaged 30 percent for both varieties, which is well below the optimum range, suggesting oil production may not be feasible in the short-season climate of the Klamath Basin. Excessive heat during late July and early August may have contributed to the low oil content. However, the 2001 season was not uncommonly warm overall. Fall establishment of cold hardy varieties would likely facilitate early harvest and could provide conditions for greater oil production.

Summary

The main objective of the study was to determine if flax could reach physiological maturity in the cool, short-season climate of the Klamath Basin. Length of growing season in the Klamath Basin appears to be adequate for flax production although late summer heat may reduce oil content. Frequent frosts during the growing season are common occurrences. Flax plants can withstand temperatures to 24°F. Most areas in the region would be conducive for flax production although cold pocket areas such as Lower Klamath and Copic Bay may experience temperatures below 24°F. Additional research to evaluate fall establishment is needed to adequately assess effects of frost on fiber and oil production.

A wide array of products made from flax includes linseed oil, car-door panels, edible oil and grains, pet and animal food supplements, linen, paper, linoleum, and automotive components. This indicates many marketing opportunities may exist for local production. A good example may be as a ration supplement for a large poultry industry in California. Additional research is needed to further define yield, economic potential, and determine optimum cultural practices for flax production in the Klamath Basin.

References

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Flax Council of Canada. www.flaxcouncil.ca/flaxnut9.htm.

Table 1. Field-dry fiber yield and plant height of four flax varieties planted May 8, 2001 at U.S. Timberlands Tree Nursery, Yonna Valley, OR.

Variety	Field-dry straw yield (lb/acre)	Extractable fiber yield (lb/acre)[1]	Plant height (75% boll formation)[2]
Argos	8600	1720	37
Viking	6975	1395	32
Elise	8050	1610	35
Viola	8650	1730	38
Mean	8067	1614	35
CV (%)	15.4	15.4	9.4
LSD (0.05)	NS	NS	NS

[1]Estimated as 20.0% of field-dry weight (includes long and short fiber).

[2]Height expressed in inches.

Table 2. Field-dry seed yield and percent oil content of two flax varieties planted May 8, 2001 at U.S. Timberlands Tree Nursery, Yonna Valley, OR.

Variety	Field-dry seed yield (lb/acre)	Field-dry oil yield (lb/acre)[1]	% Oil content[2]	
			Field-dry	Oven-dry
Neche	1185	382	32.2	30.1
Omega	1410	480	34.1	30.3
Mean	1298	431	33.2	30.2

[1]Field-dry oil yield calculated from field-dry seed yield and field-dry oil content -- 10% moisture.

[2]Oil content = field-dry approximately 10% moisture; oven-dry near 0% moisture (50°C for 48 hours).

Control of Canada Thistle with Herbicides

Jim E. Smith and Donald R. Clark[1]

Abstract

A trial was established at the Klamath Experiment Station Worden Site at Lower Klamath Lake to evaluate efficacy of herbicides for control of Canada thistle (*Cirsium arvense*) in pasture. Chemicals evaluated included Transline® (clopyralid, Dow Agroscience), Ally® (Metsulfuron, E.I. duPont), Weedmaster® (a combination of Dicamba and 2,4-D Amine, BASF), and Roundup Ultra® (glyphosate, Monsanto). Twelve treatments included herbicides used alone, or in tank mix combinations, with Transline at two application rates. Treatments were evaluated for early vigor control and percent desiccation, and regrowth several times prior to frost-induced dormancy. Transline, alone or in combination, was most effective in reducing regrowth. Ally was least effective in early visual control and regrowth prevention. All treatments were similar in desiccation rate. Control ratings will not be finalized until regrowth is evaluated in spring 2002.

Introduction

Canada thistle has become a very persistent and problematic plant in our current agriculture production system by competing with crops, contaminating forages, and reducing pasture productivity and quality. Klamath Experiment Station (KES) currently operates a pasture on a muck soil experimental site at Lower Klamath Lake, close to Worden, Oregon. Canada thistle has invaded and spread at this site, providing an opportunity to evaluate control measures. A replicated trial was established to investigate herbicides individually and in combinations of Transline with Weedmaster, Ally, and Roundup Ultra for control of Canada thistle. Efficacy was measured through the 2001 growing season, and will be re-evaluated in 2002 for long-term effectiveness.

Canada thistle is a native of Eurasia and was introduced to America around 1750 (Whitson, 1996). Canada thistle is a profusely rooting perennial noxious weed. It can reproduce from seed or vegetatively from underground nodes. Canada thistle is a dioceous plant, requiring both male and female plants for sexual reproduction. Plants bloom when day length reaches 14 to 16 hours. Seed production ranges from up to 100 seeds per head, to 5,000 seeds per plant. Seeds are viable 8-10 days after blooming and maintain viability for up to 20 years in the soil. Extensive roots allow vegetative propagation, with horizontal growth up to 15 ft at depths from 6 to 15 ft. New plants can develop from pieces as small as 0.25 inches long and 0.125 inches in diameter. These pieces can survive 100 days without photosynthesis. A 6- to 8-week old plant can produce new growth from roots if its top is removed. Roots exude toxins inhibiting neighboring species. Canada thistle forms patches wherever it grows (spreading rhizomes), and each patch is of one sex. Male plants do not form seed. Seed from the female plant is wind

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blown, enhanced by the attached plumose bristles.

Transline is a plant growth regulator (auxin imitator), which is active on many broadleaf plants and some grasses. It has foliar and soil activity with a 15- to 84-day half-life. It is a liquid material containing 3 lb/gal active ingredient (ai). There are no grazing restrictions on this compound; however, it is concentrated in the urine of livestock feeding on treated plants, and can be deposited with the urine. Therefore, it is recommended that livestock be fed untreated hay prior to moving to a susceptible crop, such as mixed pasture containing beneficial broadleaf plants. Residue from treated plants should not be used for any growing purpose, especially not as compost for gardens, since the active ingredient remains within the plant and can cause damage to susceptible plants.

Ally is a dry flowable granule containing 60 percent ai by weight. Ally is a sulfonylurea compound absorbed through the foliage of broadleaf weeds, and the label recommends application to young, actively growing weeds. Ally is an amino acid inhibitor, causing meristems to cease growth with accompanying growth symptoms, such as yellow, pink, and purple coloration. Ally works slowly, requiring up to 3 weeks for symptoms to develop. There are no grazing restrictions following application of Ally.

Weedmaster, a combination of dicamba at 1 lb/gal ai and 2,4-D Amine at 2.87 lb/gal ai, is a synthetic auxin, or plant growth regulator. Typical symptoms occurring from treatments with this compound include epinasty, or distorted new growth. Dicamba has foliar and soil activity, while 2,4-D has mainly foliar activity. Grazing restrictions for pasture application include 7 days for lactating livestock, none for non-lactating livestock, and 30 days to slaughter restriction. Haying restrictions require a 37-day preharvest interval (PHI).

Roundup is a foliar-applied, amino acid inhibiting compound, effective against a great number of weeds, including perennial, annual, broad-leaved, and grass weeds. Thorough coverage is important for this product, and the presence of dust on foliage can deactivate the active ingredient, as does soil contact. This product translocates throughout the plant. Timing of applications is important for control of certain weeds. For example, best control of perennial weeds is in the fall as the root receives carbohydrate reserves for overwinter survival, and also the applied glyphosate. Various formulations of this product are available, ranging in concentration from 5-lb/gal ai (our trial formulation), to minute quantities found in products in home and garden sections of retail outlets. Roundup has an 8-week preharvest interval restriction.

Procedures

Plots consisted of a minimum number of plants, (approximately 4-5 each), encompassing 5.5 ft by 15 ft per plot. Ten treatments were arranged in a randomized block design with three replications. Herbicide treatments were applied July 6-9, 2001, to plants prior to and/or just following initial bloom. Chemicals used in the trial included Transline, Ally, Weedmaster, Roundup Ultra, and R-11 Spreader (Wilbur-Ellis). Herbicides were used alone and in tank mixes. Tank mixes included two rates of Transline.

Plot visual control ratings were recorded several times prior to dormancy, with 100 = 100 percent control, 0 = 0 percent control; and regrowth was rated 1-10, with 10 = no regrowth and 1 = total regrowth. Canada thistle plants were healthy and vigorously growing prior to herbicide applications. Plots were sprayed with a CO_2 backpack sprayer calibrated to provide 30 gal/acre at a calibrated walking speed of 1.6 miles/hour, and timed with a metronome at 70 steps/minute. Spray tips were 8003 flat fan nozzles operated at 40 psi. The spray boom had 3 tips, 20 in apart, and covered a swath of 5 ft.

Treatments included the following:

1. Transline at 1.33 pt/acre plus Weedmaster at 2 pt/acre.
2. Transline at 1.33 pt/acre plus Roundup Ultra at 2 pt/acre.
3. Transline at 1.33 pt/acre plus Ally at 0.33 oz/acre.
4. Transline at 1.33 pt/acre.
5. Transline at 0.66 pt/acre.
6. Transline at 0.66 pt/acre plus Weedmaster at 2 pt/acre.
7. Transline at 0.66 pt/acre plus Roundup Ultra at 2 pt/acre.
8. Transline at 0.66 pt/acre plus Ally at 0.33 oz/acre.
9. Roundup Ultra at 2 pt/acre.
10. Weedmaster at 2 pt/acre.
11. Roundup Ultra at 2 pt/acre plus Weedmaster at 2 pt/acre.
12. Ally at 0.33 oz/acre.

Note that all treatments received R-11 spreader at 2 pt/acre, and no check plot was deemed necessary due to the abundance of nearby healthy and untreated plants available for comparison.

Results and Discussion

Treatments were rated visually on early control, desiccation, and regrowth. There were no statistical differences between treatments for desiccation as all were rated at full desiccation (Table 1). Ratings for early control showed best results with Transline + Roundup Ultra at both rates of Transline, Transline plus Weedmaster at the low rate of Transline, Transline alone and Transline plus Ally at the high rate of Transline, and Weedmaster plus Roundup Ultra. All treatments were initially active, as evidenced by the total desiccation ratings (100 percent). Six out of 12 treatments exhibited excellent early control. Ally alone was significantly less effective than all other treatments for early control.

Ratings for regrowth showed only four treatments in the top control level: Transline plus Weedmaster, Transline plus Ally, and Transline plus Roundup Ultra, all at the high rate of Transline, and Transline alone at the low rate. The apparent anomaly for Transline at the high rate may be due to rapid early desiccation, which prevented full translocation of product to the root system.

Canada thistle regrowth measured in the spring of 2002 will provide more data on control measure effectiveness, since any plants or parts of plants that have died, will not regenerate. This information will be reported in the 2002 report.

References

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Table 1. Early visual control rating, visual desiccation, and number of Canada thistle plants regrowing following herbicide treatments, Worden, OR, 2001.

Herbicide	Rate	Early Visual Control	Visual Desiccation	Number Regrowing
Transline Weedmaster	1.33 pt/acre 2 pt/acre	50 bcd[1]	100 a	2.0 a
Transline Roundup Ultra	1.33 pt/acre 2 pt/acre	73 a	100 a	4.7 ab
Transline Ally	1.33 pt/acre 0.33 oz/acre	70 a	97 a	4.7 ab
Transline	0.66 pt/acre	50 bcd	90 a	5.0 abc
Roundup Ultra	2 pt/acre	53 ab	90 a	6.7 bcd
Transline	1.33 pt/acre	70 a	97 a	7.3 bcd
Weedmaster	2 pt/acre	47 cd	73 a	7.7 bcd
Weedmaster Roundup Ultra	2 pt/acre 2 pt/acre	67 a	93 a	8.7 bcd
Transline Ally	0.66 pt/acre 0.33 oz/acre	60 abc	83 a	8.7 bcd
Transline Roundup Ultra	0.66 pt/acre 2 pt/acre	70 a	90 a	9.3 cd
Transline Weedmaster	0.66 pt/acre 2 pt/acre	70 a	83 a	10.0 d
Ally	0.33 oz/acre	37 d	70 a	10.0 d
CV (%)		16	14	39
LSD (0.05)		17	NS	5

[1]Values within columns followed by the same letter are not significantly different (p=0.05).

Early Spring Establishment of Cereals for Dryland Cover Crops and Their Production Potential

Donald R. Clark and Jim E. Smith[1]

Abstract

With the drought and lack of irrigation water for the 2001 growing season, a need developed to provide cover for fields with insufficient plant residues to prevent wind erosion damage. Fields that had grown potatoes and onions the previous year were most vulnerable to springtime winds. To investigate the suitability of small grains for this purpose, plots were established on the mineral soil at the Klamath Experiment Station (KES) with eight small grain varieties. Entries included barley, wheat, rye, oats, and triticale. Both spring and winter varieties were seeded on April 16. Frosts after seeding caused leaf burn and some plant death. Cayuse oats had the most plant death due to these early frosts. An early vigor rating indicated that 102 winter triticale, Trical 2700 spring triticale, common winter rye, and Xena spring barley exhibited the most vigor. None of the three winter cereals produced reproductive tillers. They would have been most suitable for grazing and less for haying. For the heading varieties, Trical 2700 triticale and Xena barley produced the most hay from cuttings 9 and 11 weeks after seeding. The non-heading winter cereals produced higher forage quality than headed cereals. For the varieties that were hayed, Sprinter and Xena barley produced hay with higher forage quality than Trical 2700 triticale. Trical 2700 triticale produced the most grain, about 1 ton/acre, while Sprinter barley produced about 0.5 ton/acre.

Introduction

Concerns were raised about wind erosion with the announcement on April 6, 2001 that water from the Klamath Project would not be available to most irrigators during the 2001 growing season. Fields that had grown grain, hay, or other similar crops had adequate cover from vegetative residues to prevent wind erosion damage. The chief concern was fields that had grown potatoes or onions during the 2000 growing season or that were fall-prepared for 2001 row crops. At KES, two fields had grown potatoes in the 2000 season and by early April were beginning to lose topsoil. On April 16, a particularly windy day, a series of car accidents occurred due to blowing dust that reduced visibility on Highway 97, just north of Klamath Falls.

With the lack of potential income from dryland fields, the cost of establishing cover crops was a concern to producers. To alleviate these concerns, the Natural Resource Conservation Service (NRCS) provided two million cost-share dollars to implement a portion of the Emergency Watershed Protection (EWP) program. Over 29,000 acres of land were enrolled in this program in the Klamath Basin. This program provided between 30 and 40 dollars/acre for cover crop establishment, and allowed producers to harvest these acres provided 1,000

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lb/acre of vegetative residue remained. This allowed producers a chance to either hay or graze established cover crops.

A trial was established at KES to determine the most appropriate small grain to use for a non-irrigated cover crop and the production potential for such a crop. The trial included evaluations of early crop vigor, stand counts, yields from two forage hay harvests, forage quality for the second cutting, and grain yield.

Procedures

The trial was established on a field with Poe fine sandy loam soil that had grown potatoes the previous year. Residues from this crop had been raked and burned leaving the soil bare, with the potential for wind erosion damage. The field was ripped to 12- to 18-in depth in November, prior to cover crop establishment. Eight varieties in the trial included Xena spring barley, Sprinter facultative barley, Stephens soft white winter wheat, Twin hooded wheat, 102 winter triticale (hybrid between wheat and rye), Trical 2700 facultative triticale, Cayuse oats, and common winter rye. Grain was seeded on April 16, 2001 using a Great Plains direct-seeding drill into 14- by 600-ft plots. Seeding rate was 60 lb/acre with seeding depth 2-3 in to reach moisture. Three replications were used in a randomized complete block design.

Three weeks after seeding (WAS), visual vigor ratings and plant heights were measured on the plots. At 9 WAS, plant heights were measured and forage material was removed from two random 2.8-ft^2 quadrants by cutting 0.5 in above the soil surface. This material was dried for 48 hours at 140°F to determine dry weight yields. A plant count was also completed at this time. During the trial, three of the cereals, Stephens winter wheat, 102 winter triticale, and the common winter rye, did not receive adequate vernalization conditions to produce reproductive tillers. Following the first quadrant harvest, the middle 9 ft of each plot of productive tillering entries was swathed and removed as hay. At 11 WAS, plant heights were measured from plot borders and from the regrowth from previously swathed plot centers. Forage material was harvested from the uncut and regrowth portions of plots and dried as above to obtain dry weight yields. Material was ground twice, once to pass a 2-mm-sieve screen with a Wylie Mill, and then to pass a 1-mm-sieve screen with a Udy Mill, and analyzed using a near infrared spectrophotometer (NIRS) to determine acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude protein (CP). From these forage quality attributes, the total digestible nutrients (TDN) and relative feed value (RFV) were calculated. The formulas for these calculations are:

$$TDN = [\ 82.38 - (\ 0.7515 * ADF)\ ] * 0.9$$

$$RFV = \{\ [\ 120 / NDF\ ] * [\ 88.90 - (0.779 * ADF)\ ]\ \} / 1.29$$

Grain from the uncut plot borders was harvested with a 4.5 ft-wide header Hege (Hans-Ulrich Hege) plot combine at 17 WAS. Grain from each plot was weighed for yield and test weights were determined from one replication for all varieties. In addition, plumps and thins were determined for the two barley varieties. All data were analyzed statistically using SAS software for a randomized complete block design.

Results and Discussion

The AgriMet station located at KES recorded total precipitation of 1.71 in during the trial. This included 0.57 in of rain 2 days after seeding (DAS) and 0.64 in 4 WAS. These rainfall events provided sufficient moisture for seed germination and plant establishment. Thirteen frosts occurred during the trial, including temperatures of 24°F 13 DAS, 23°F 16 DAS, and 26°F 7 WAS. The last spring frost occurred 8 WAS. These frosts caused burning of leaf material and stand reductions.

Data collected 3 WAS on visual vigor ratings and plant heights are included in Table 1. The two triticale (manmade hybrids between wheat and rye) varieties and the winter rye demonstrated the most vigor among the eight cereals. This was evident both in the visual vigor ratings and in plant height measurements. This seems logical, as rye is known as one of the more cold-hardy cereals. On the other end of the scale, Cayuse oats was visibly the least vigorous and shortest of the tested cereals. Forage data from harvests completed 9 and 11 WAS further documented injury to oats (Table 2).

Height measurements of the cereals at the first forage harvest showed that Xena barley, Trical 2700 triticale, and Cayuse oats were the tallest. For reproductive cereals, Sprinter barley was significantly shorter than other reproductive cereals. Common rye, 102 triticale, and Stephens wheat did not produce seed heads and were shorter than those that did head out. The reduced height was also evident in the yield component for both harvests. Top forage yields for the first harvest were observed for Trical 2700 triticale, Xena barley, Twin wheat, and Sprinter barley.

A noticeable increase in height was observed for Trical 2700 triticale from the first to the second cutting. Variations in yields within plots due to water stress resulted in large coefficients of variation (CVs) and least significant differences (LSDs) (Table 2). As a result, none of the reproductive cereals were significantly different from each other in forage yield at 11 WAS. Trical 2700 triticale produced the tallest regrowth following the first harvest. However, this height advantage did not translate to increased regrowth forage yield. Though not the tallest, Twin wheat and Sprinter barley produced the highest amount of regrowth matter due to more shoots.

Though forage yields were less for the cereals that only produced vegetative growth, forage quality was better than for seed-producing varieties (Table 3). Among vegetative entries, the major difference in quality was that winter wheat and triticale exhibited higher CP than the rye. For heading entries, the two barley varieties produced less ADF and NDF than triticale. The increased height and thus increased stem material for triticale accounted for its higher fiber content.

Grain yields and quality for the cereals are reported in Table 4. Triticale produced significantly more grain (1,900 lb/acre) than other entries except Cayuse oats, while Sprinter barley produced the least at 930 lb/acre. Under irrigated conditions in the previous year's grain variety trials, Trical 2700 triticale and Cayuse oats both produced over 3 tons/acre.

Test weights for the Cayuse oats were similar to those observed in previous years under irrigation. Barley test weights averaged over 54 lb/bu in a 37-entry barley variety trial under irrigation in 2000. In the 2001 trial, Xena produced similar test weights, but Sprinter had lower test weights than in 2000 by over 7 lb/bu. However, in this trial Sprinter had more plumps than Xena (85 percent compared to 73 percent). In the 2000 trial, barley varieties averaged 95 percent plumps, indicating the dryland conditions definitely reduced the percentage of plumps compared to irrigated conditions last year.

Table 1. Cover crop vigor and height 3 weeks after seeding for eight cereal varieties grown at Klamath Falls, OR, 2001.

Type and (Variety)	Vigor	Height
	visual	in
Winter triticale (102)	9 a[1]	3 a
Facultative triticale (Trical 2700)	9 a	3 a
Winter rye (Common)	8 ab	3 a
Spring barley (Xena)	7 b	2 b
Spring hooded wheat (Twin)	5 c	2 b
Facultative barley (Sprinter)	4 c	2 b
Winter wheat (Stephens)	4 c	2 b
Spring oats (Cayuse)	2 d	1 c
Mean	6	2
CV (%)	12	14
LSD (0.05)	1	1

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 2. Plant stands, cover crop height, and forage yield of eight cereal varieties 9 and 11 weeks after seeding (WAS) and height and forage yield of regrowth 11 weeks after seeding and 2 weeks after initial cutting at Klamath Falls, OR, 2001.

Type and (Variety)	9 WAS			11 WAS		Regrowth	
	Number	Height	Yield	Height	Yield	Height	Yield
	plant/ft²	in	lb/acre	in	lb/acre	in	lb/acre
Facultative triticale (Trical 2700)	22 bc[1]	21 ab	5260 a	36 a	8660 a	15 a	270 c
Spring barley (Xena)	25 bc	23 a	3820 b	24 b	5950 a	10 ab	270 c
Spring oats (Cayuse)	14 d	19 abc	2670 cd	22 b	5930 a	7 b	480 b
Facultative barley (Sprinter)	29 ab	16 c	3120 bc	15 c	5850 a	11 ab	570 ab
Spring hooded wheat (Twin)	33 a	18 bc	3640 b	20 b	5530 ab	9 b	680 a
Winter rye (Common)	25 bc	11 d	2230 de	10 d	2890 bc	---	---
Winter triticale (102)	28 ab	8 d	1800 de	10 d	2540 c	---	---
Winter wheat (Stephens)	18 cd	9 d	2100 de	9 d	2160 c	---	---
Mean	24	16	3080	19	4890	10	460
CV (%)	19	15	14	13	32	26	18
LSD (0.05)	8	4	730	4	2760	5	160

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 3. Cover crop forage quality of eight cereal varieties as acid detergent fiber (ADF), neutral detergent fiber (NDF), crude protein (CP), total digestible nutrients (TDN), and relative feed value (RFV) from cuttings 11 weeks after seeding at Klamath Falls, OR, 2001.

Type and (Variety)	ADF	NDF	CP	TDN	RFV
	%	%	%	%	
Winter wheat (Stephens)	23 a[1]	41 a	20 a	59 a	164 a
Winter rye (Common)	23 ab	42 a	17 bc	59 ab	157 a
Winter triticale (102)	23 ab	43 a	19 ab	59 abc	155 a
Facultative barley (Sprinter)	27 bc	50 b	15 cd	56 bcd	129 b
Spring barley (Xena)	27 bc	50 b	13 d	56 cd	128 b
Spring oats (Cayuse)	30 cd	53 bc	16 cd	54 de	116 bc
Spring Hooded Wheat (Twin)	30 cd	53 bc	15 cd	54 de	115 bc
Facultative triticale (Trical 2700)	34 d	58 c	14 cd	52 e	101 c
Mean	27	49	16	56	133
CV (%)	9	6	11	3	10
LSD (0.05)	4	5	3	3	22

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 4. Cover crop grain yields and grain quality of eight cereal varieties grown at Klamath Falls, OR, 2001.

Type and (Variety)	Yield	Test weight	-----% above sieve-----		
			6/64	5.5/64	pan
	lb/acre	lb/bu			
Facultative triticale (Trical 2700)	1900 a[1]	54.5	---	---	---
Spring oats (Cayuse)	1670 ab	41.0	---	---	---
Spring barley (Xena)	1490 b	53.5	73	19	8
Spring hooded wheat (Twin)	1320 b	60.5	---	---	---
Facultative barley (Sprinter)	930 c	46.5	85	10	5
Winter triticale (102)	---	---	---	---	---
Winter rye (Common)	---	---	---	---	---
Winter wheat (Stephens)	---	---	---	---	---
Mean	1465	51.2	79	15	7
CV (%)	14	---	---	---	---
LSD (0.05)	370	---	---	---	---

[1]Values within a column followed by the same letter are not significantly different (p = 0.05).

Early Spring Establishment of Cereals to Determine Vernalization and Production potential

Donald R. Clark and Jim E. Smith[1]

Abstract

A trial was established to determine vernalization and yield potential of selected winter cereals. These included Bogo and Celia winter triticale and Stephens, Nugaines, Lambert, and Yamhill winter wheat. For comparison, Alpowa spring wheat, Baronesse and Xena spring barley, and Sprinter, a facultative barley, were included. Seven weeks after seeding (WAS), Baronesse and Xena barley exhibited the most vigor for the varieties. By harvest time, all of the varieties had formed reproductive tillers except for Lambert and Yamhill winter wheat. Baronesse, Xena, and Bogo produced the most grain. Without irrigation, grain production was less than 1,000 lb/acre.

Introduction

Initial data indicate that triticale has the potential to provide Klamath Basin growers a source of grain and forage. Trials at the Klamath Experiment Station (KES) during the 2000 growing season included two spring varieties of triticale with production averages of 6,490 lb/acre. In a similar trial on a Lower Klamath Lake (LKL) site, yields averaged 5,290 lb/acre. This LKL trial experienced a severe frost when the cereals were about 4 in tall, which reduced yields. In a cover crop trial at KES in the 2001 growing season, forage production of over 4 tons/acre was achieved with no in-season irrigation.

Over the past 4 years, Oregon State University Extension and Research trials have investigated triticale varieties developed by a group of breeders at the Plant Breeding and Acclimatization Institute, Malyszyn Experiment Station, Poland. Most of these efforts have focused on two varieties, Bogo and Alzo. These varieties were introduced to the United States by Dr. Bob Metzger, retired Agricultural Research Service (ARS) geneticist and long-time triticale believer and breeder, and by Resource Seeds, a triticale breeding company in California. In a fertility trial near Corvallis, Oregon in 1999, Bogo, with 200 lb/acre spring-applied nitrogen, had an average grain yield of 11,280 lb/acre. In an adjoining variety trial, Bogo yielded 10,680 lb/acre, while Madsen winter wheat produced 9,060 lb/acre. Madsen is one of the two leading soft white wheats grown in the state. In an adjoining statewide variety trial, Bogo and Madsen averaged 9,790 and 9,060 lb/acre, respectively.

Steve Orloff, University of California at Davis Siskiyou County Farm Advisor, has been investigating winter triticale for springtime grazing in April before the cereal is in the jointing stage. If livestock could be removed after this early season grazing, a hay or grain crop could also be produced. This practice of obtaining early grazing and a later crop is common in more temperate regions of the country, especially the high plains of Texas and New Mexico. Stand losses from winter temperatures

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have prevented this from being more common in the Klamath Basin. The winter climate in the Klamath Basin has been a major reason that spring grain far exceeds winter grain production. Spring frosts during winter grain pollination also limit production of fall-planted grain.

To produce heads, a vernalization period of cold temperatures is required for winter grains. Interest was expressed by the Wilbur-Ellis Company in determining if the cold temperatures of March and April could vernalize these high-producing triticales and avoid the adverse winter climate in the Klamath Basin. A trial was thus established at KES with Bogo triticale, winter and spring wheats, and spring barleys.

Procedures

The trial was established on a Poe fine sandy loam soil, in a field that had grown forage and grain sorghum the previous year. The sorghum residue was chopped and incorporated with three passes of a tandem-disk. Ten varieties in the trial included Bogo and Celia (winter triticales), Stephens, Nugaines, Lambert, and Yamhill (soft white winter wheats), Alpowa (soft white spring wheat), Sprinter (facultative barley), and Baronesse and Xena (spring barley). Seed was planted at 1-in depth at 15 and 30 seeds/ft^2 with a Kincaid plot planter on March 12 in a 10 by 2 factorial randomized block design with three replications. Plots were 4.5 ft wide (9 rows at 6-in spacing) and 20 ft long. Along ends of plots, 5.5-ft-wide borders were shredded resulting in 14.5- by 4.5-ft harvest areas. All plots were fertilized with 50 lb N, 25 lb P_2O_5, 25 lb K_2O, and 44 lb S/acre banded at planting (16-8-8-14 at 315 lb/acre). No irrigation was applied. During the trial, 2.81 in of precipitation was recorded. This precipitation occurred in 34 events with 12 days of over 0.1 in. The largest events included 0.25 in on March 27, 0.33 in on April 18, and 0.48 in on May 15. Below-freezing temperatures were recorded on 38 nights; 4 of these were below 20°F and 14 nights were between 20°F and 25°F.

Seven weeks after seeding (WAS) and 2 days after a 23°F frost, visual vigor ratings were taken on the plots. These ranked the plots from 0, total death, to 100, no injury, on leaf burn, size, and stand establishment. During the trial, two of the winter wheats, Lambert and Yamhill, did not receive adequate vernalization conditions to cause reproductive tillering. The rest of the plots were harvested 22 WAS with a 4.5-ft-wide header Hege (Hans-Ulrich Hege) plot combine. Grain was moisture tested and yields were adjusted to 10 percent moisture content. All data were analyzed statistically using SAS software for a 10 by 2 factorial in a randomized complete block design.

Results and Discussion

Vigor ratings, 10 percent moisture yields, and test weights are presented in Table 1. The most vigor was exhibited by the barleys Xena, Baroness, and Sprinter. Triticale and wheat varieties were significantly less vigorous than any of the barley varieties and were similar to each other in vigor except for the least vigorous selection, Celia. Celia's lack of vigor was mainly due to low establishment numbers.

Except for Lambert and Yamhill, all of the varieties vernalized and produced reproductive tillers. Grain yields were seriously reduced in this trial due to the lack of water during the growing season. Stored moisture in the soil at the start of the trial plus the 2.81 in of rainfall was inadequate to allow the genetic potential of the varieties to be expressed. The two seeding rates did not differ from each other and no seeding rate by variety interaction was indicated. Thus the data presented are the average of the two seeding rates.

Highest yielding varieties in the trial were Baronesse, Xena, and Bogo. However, production was less than 1,000 lb/acre. It is unknown if the ranking of these entries would have changed with adequate moisture. Nugaines, Alpowa, and Sprinter produced less grain than the other entries. Test weights for all entries were less than typically observed under irrigated production in the region.

Table 1. Cereal vigor of 10 varieties 7 weeks after seeding and grain yield and test weights 22 weeks after seeding averaged over two seeding rates grown at Klamath Falls, OR, 2001.

Type and (Variety)	Vigor	Yield	Test weight
	visual	lb/acre	lb/bu
Baronesse (Spring barley)	74 b[1]	950 a	49.7 d
Xena (Spring barley)	82 a	780 ab	47.1 e
Bogo (Winter triticale)	47 de	720 abc	50.2 d
Stephens (Soft white winter wheat)	40 e	560 bcd	53.8 b
Celia (Winter triticale)	22 f	420 cd	52.2 c
Nugaines (Soft white winter wheat)	42 de	290 d	60.8 a
Alpowa (Soft white spring wheat)	48 d	280 d	60.0 a
Sprinter (Facultative barley)	66 c	260 d	44.6 f
Lambert (Soft white winter wheat)	40 e	--[2]	--
Yamhill (Soft white winter wheat)	42 de	--[2]	--
Mean	51	530	52.3
CV (%)	12	52	2
LSD (0.05)	7	320	1.4

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).
[2]Varieties did not vernalize, resulting in no grain yields.

Spring Small Grain Seeding Rate Trial at Lower Klamath Lake

Donald R. Clark and Jim E. Smith[1]

Abstract

A seeding rate trial was conducted on a site at Lower Klamath Lake (LKL), Oregon that had received pre season winter flooding as the only source of irrigation. This trial investigated two varieties each of spring barley, oats, and wheat, at seeding rates of 10, 20, 30, and 40 seeds/ft^2. Common practices in the area under winter flood and in-season irrigation would call for seeding rates of 30 seeds/ft^2. Highest yields from this trial tended to occur at seeding rates less than 40 seeds/ft^2. With increasing seeding rates, test weights increased while plant height and heading dates decreased.

Introduction

The winter flooding of crop land is a unique irrigation practice conducted on the high water-holding capacity soils of LKL. These high organic matter muck soils can hold upward of 5 in of water per foot of soil. Many of these soils are underlain with clay layers found at depths of 12 in or more. These semi-permeable clay layers tend to impede but not totally prevent water and root penetration. The high amounts of water applied during the winter floods restore water to the soil profile in addition to leaching accumulated salts away from crop rooting zones. In the past, it was a common practice for this winter flood to be the only irrigation water for the growing of spring-planted small grains. Yields approaching 3,000 lb/acre could be expected with this practice. More recently, in-season irrigation along with improved varieties and other agronomic techniques have doubled expected yields. A lingering drought and altered water allocation policy caused much of the LKL area to be denied in-season irrigation water during the 2001 growing season. This resulted in grain crops being grown only with the winter preseason flood.

Although this practice was common in earlier times, it was not known how the improved varieties of spring small grains would react to the more dryland conditions. Previous work has shown that winter cereals are capable of increasing seedhead tillers, compensating for low stand counts, with minimal loss of grain yields. However, with the shorter growing season of spring grains, tiller production is limited and stand populations are more correlated with yields. Most spring grain yield is produced from the main stem and the first tiller. Harvest problems arise when immature grain from later emerging tillers is combined with the mature majority of the grain.

To investigate these questions, a seeding-rate trial was established at LKL to determine appropriate seeding rates for spring barley, wheat, and oats. Moisture received during this trial totaled 0.58 in as recorded from the AgriMet Automated Weather Station located 2 miles from the trial site. This rainfall was received in 14 events. Only two of the events produced more than

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0.1 in of rain, with 0.11 in recorded on July 10 and 0.16 in recorded on August 9. Freezing temperatures occurred on 16 occasions during the test. The coldest temperatures were below 20°F on June 4 and June 13. Temperatures between 20 and 30°F were recorded on 7 nights and between 30 and 32°F on 7 nights.

Procedures

The trial was conducted on an Algoma silt loam soil in a continuous grain rotation. Spring small grain varieties evaluated included 1202 and Xena barley, Ajay and Cayuse oats, Alpowa soft white wheat, and Yecora Rojo hard red wheat. Grain was planted with a Kincaid plot planter on May 18, in a four by six randomized complete block factorial design with four replications. Seed was planted 2 in deep into moisture, at seeding rates of 10, 20, 30, and 40 seeds/ft^2. Differences in the density of the seeds among the varieties resulted in varying lb/acre of the seeds. The seeds/ft^2 seeding rates are converted to lb/acre in Table 1. Fertilizer included 70 lb N/acre shanked in before planting as anhydrous ammonia and 50 lb N, 63 lb P_2O_5, and 41 lb S/acre banded at planting (16-20-0-13 at 310 lb/acre).

During the growing season, the date to achieve 50 percent heading was noted and just prior to harvest, plant height and lodging percentages were recorded. Grain was harvested and yield recorded on September 12 with a Hege (Hans-Ulrich Hege) plot combine with a 4.5-ft-wide header. All samples were evaluated at the Klamath Experiment Station for test weights and moisture content. Grain yields were normalized to 10-percent-moisture levels. The barley samples were also graded to determine percent plumps and thins.

All data were analyzed using SAS software. In this experiment with quantitative seeding rates as treatments, parameters with significant differences were further analyzed with orthogonal polynomials to determine the form of regression analysis most applicable to fit the data. With all quadratic and cubic responses "Max R" multiple regression analysis was used to determine the most applicable polynomial equation to produce the most appropriate regression line.

Results and Discussion

Since quantitative levels of seeding rates were employed as treatments in this trial it is not appropriate to use statistical mean separation techniques to differentiate the results of the trial. However, for reference, the data are presented for yield, test weights, height, and heading date in Table 2. Interactions were exhibited between grain varieties and seeding rate for the 10-percent-moisture yields in this trial. Due to this interaction, grain varieties should be considered individually.

Significant regression curves between seeding rate and yield for the separate grain varieties are presented in Figure 1. Data from five of the six grain varieties produced significant regressions. For these five varieties, we noted an increase in yield that peaked either at the 20 or 30 seeds/ft^2 seeding rate. Yield then declined slightly at the higher seeding rate. Based on the regression equation, maximum yield of 5,030 lb/acre for 1202 barley would have been expected between 35 and 36 seeds/ft^2. Similarly, maximum yield of 5,610 lb/acre for Xena barley would have been expected between 32 and 33 seeds/ft^2; for Cayuse oats, maximum yield of 4,440 lb/acre would have been expected between 27 and 28 seeds/ft^2; for Alpowa wheat, maximum yield of 5,190 lb/acre would have been expected between 32 and 33 seeds/ft^2; and for Yecora Rojo wheat, maximum yield of 2,790 lb/acre would have been expected between 36 and 37 seeds/ft^2.

When evaluated against seeding rates, test weights for the grain varieties produced three significant regressions (Fig. 2). For varieties 1202 and Xena barley and Yecora Rojo wheat, test weights increased with increasing seeding rates. This is a bit confounding, as it seems more logical for test weights to be higher for treatments with fewer plants that would have a larger share of the available water and nutrients than for plots with a higher plant population. For percent plumps and thins, the two barley varieties exhibited no differences between varieties or among seeding rates.

Two significant regressions were found between cereal height and seeding rates (Fig. 3). Ajay oats and 1202 barley experienced decreased height with increasing seeding rates. This would be expected, as competition between plants at higher plant populations would tend to reduce plant height.

The comparison between heading date and seeding rate for both oat varieties produced significant regressions (Fig. 4). Increasing the number of plants caused the oats to reach 50 percent heading sooner. Again this is expected as limitations to moisture and nutrients generally stimulate reproductive activity.

Table 1. Seeding rates converted from seeds/ft^2 to lb/acre for barley, oat, and wheat varieties grown at a Lower Klamath Lake organic soil site in 2001.

Variety	seeds/ft^2 10	20	30	40
	lb/acre			
Barley				
1202	41	83	124	165
Xena	34	67	101	134
Oats				
Ajay	26	52	78	104
Cayuse	33	65	98	131
Wheat				
Alpowa	45	90	135	181
Yecora Rojo	44	88	133	177

Table 2. Grain yield, test weight, height, and heading dates for barley, oats, and wheat varieties at various seeding rates for cereals grown at Lower Klamath Lake, 2001.

Variety	Seeding rate	Yield	Test weight	Height	Heading date
	seeds/ft^2	lb/acre	lb/bu	in	Julian
Barley					
1202	10	3560	49.6	27	201
	20	3960	49.9	26	201
	30	4830	50.9	26	202
	40	4850	51.3	25	200
Xena	10	3260	49.3	27	201
	20	4850	51.5	25	202
	30	5620	51.5	25	201
	40	5350	52.3	25	199
Oats					
Ajay	10	3580	40.9	25	201
	20	3890	40.1	24	201
	30	3800	41.1	23	200
	40	4140	41.0	22	199
Cayuse	10	3540	39.5	30	200
	20	4440	39.0	31	198
	30	4270	39.6	29	198
	40	4050	39.5	28	196
Wheat					
Alpowa	10	3000	60.1	28	198
	20	4550	61.5	29	198
	30	5120	61.6	29	195
	40	4980	61.3	28	197
Yecora Rojo	10	1640	55.5	19	193
	20	1590	57.9	19	192
	30	2500	59.1	18	193
	40	2630	61.1	19	192

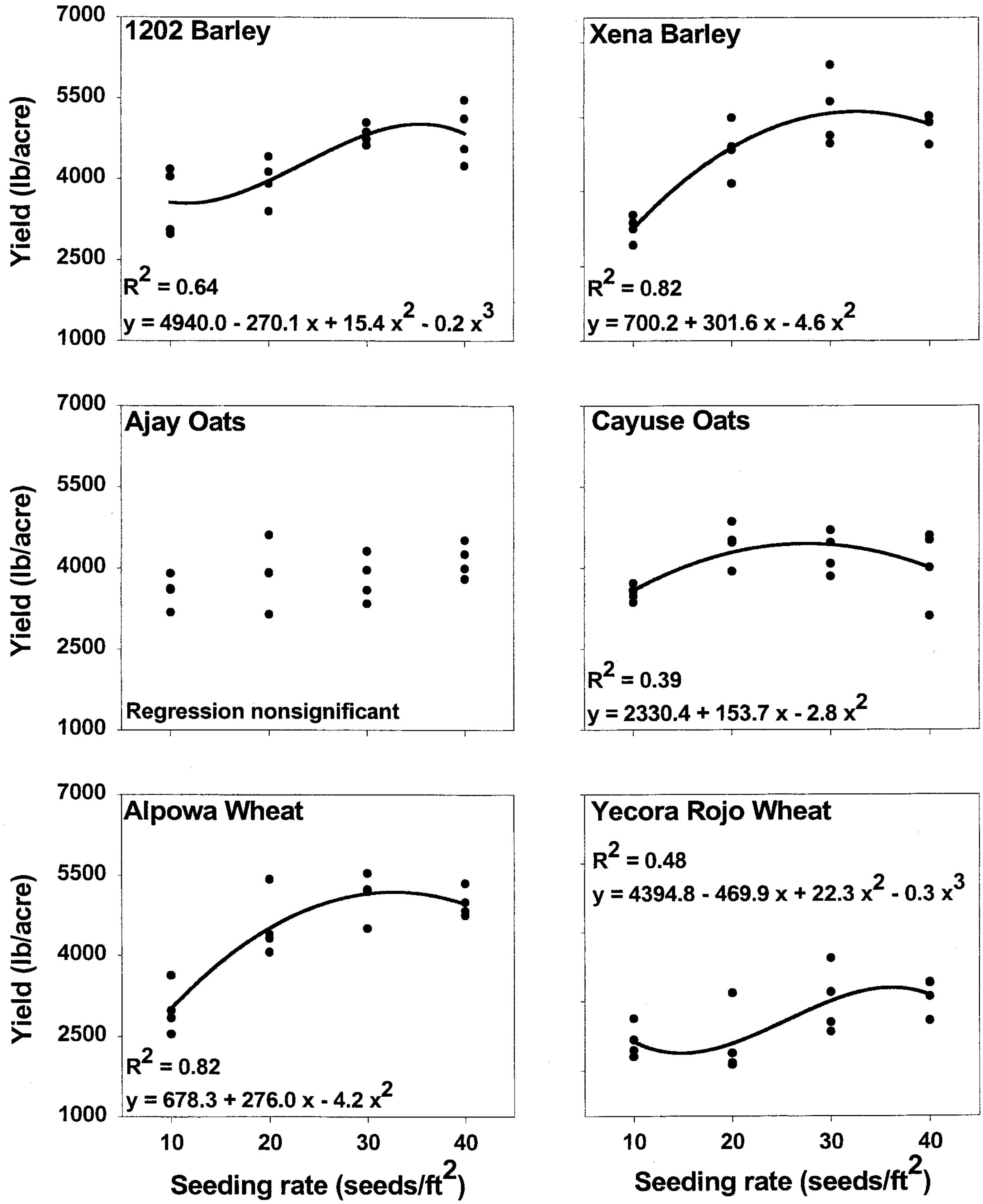

Figure 1. Regression analysis of cereal grain yields with different seeding rates, Lower Klamath Lake, OR, 2001.

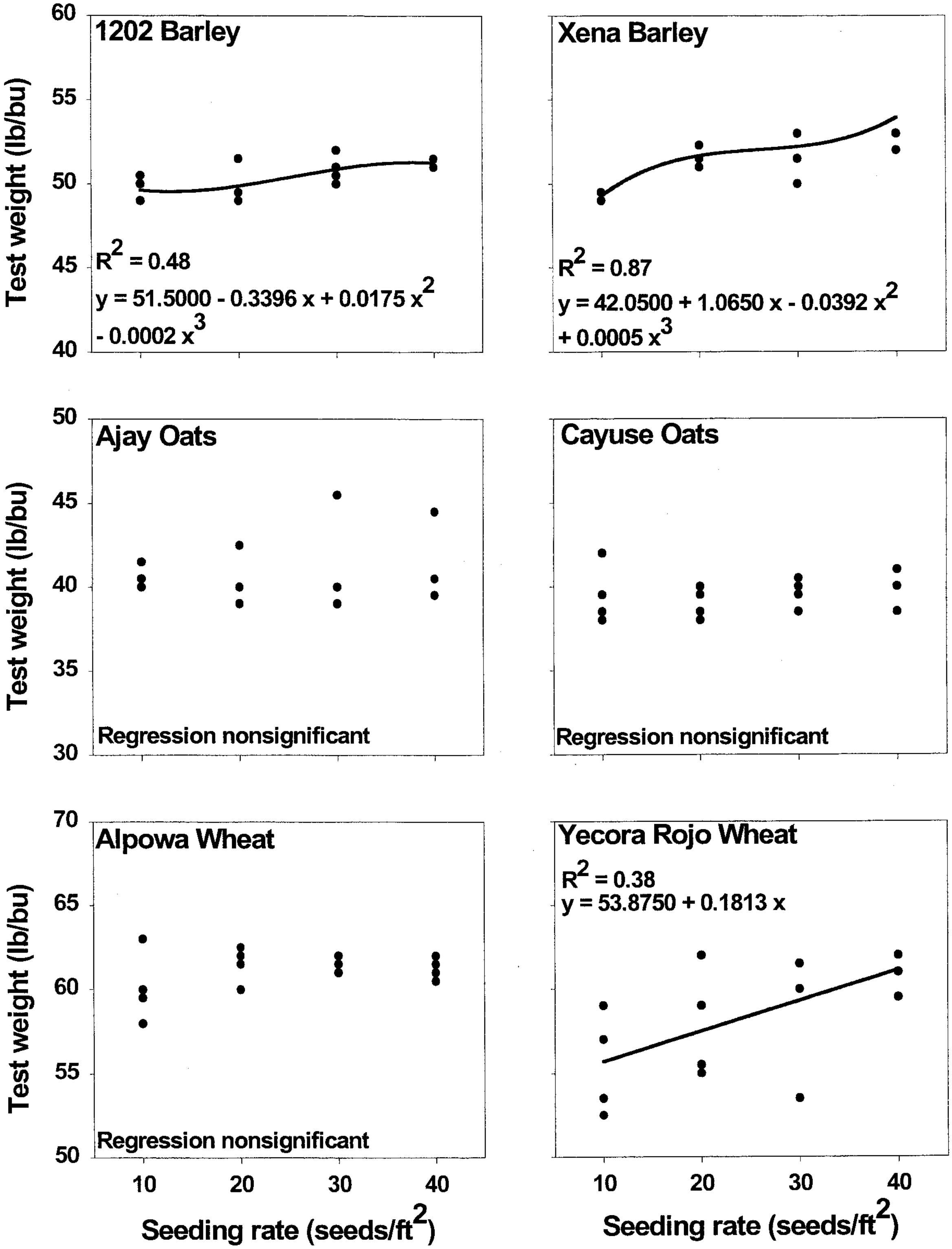

Figure 2. Regression analysis of cereal grain test weights with different seeding rates, Lower Klamath Lake, OR, 2001.

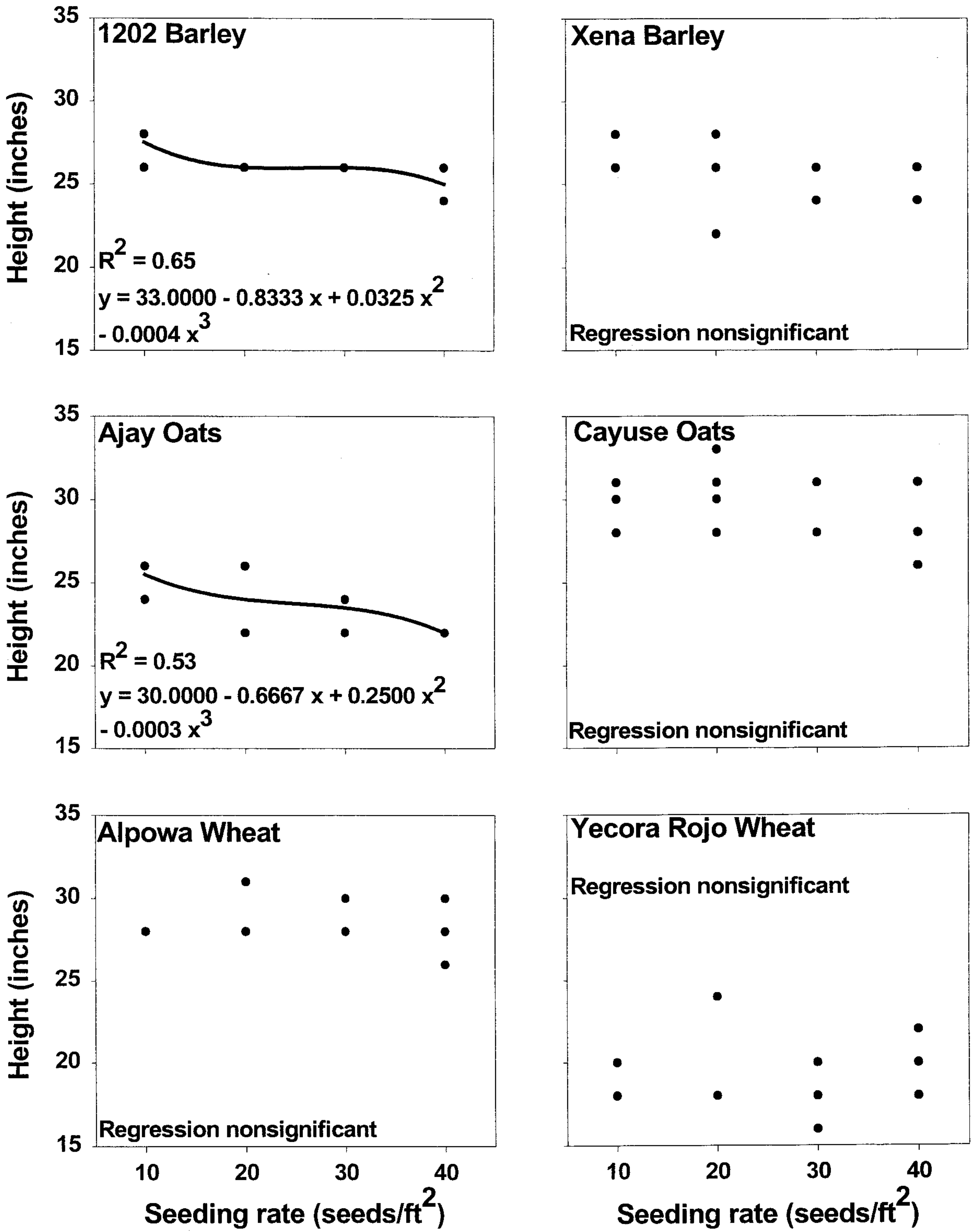

Figure 3. Regression analysis of cereal height with different seeding rates, Lower Klamath Lake, OR, 2001.

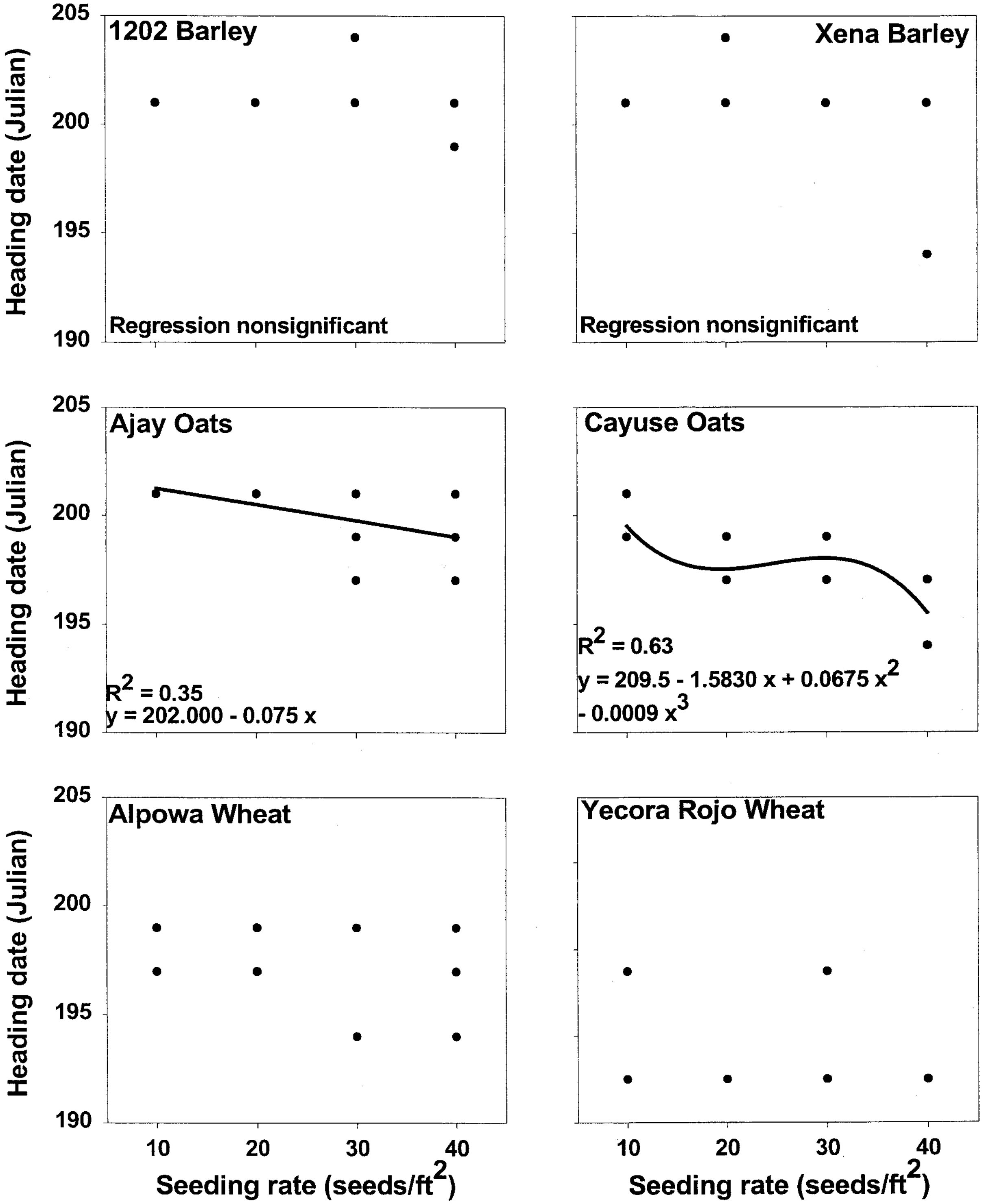

Figure 4. Regression analysis of cereal heading dates with different seeding rates, Lower Klamath Lake, OR, 2001.

Spring Small Grain (Barley, Wheat, and Oats) Variety Screening in the Klamath Basin

Donald R. Clark and Jim E. Smith[1]

Abstract

As in the past, small grain variety trials were conducted by the Klamath Experiment Station (KES) during 2001 on mineral and muck soils. However, the mineral soil trials were moved to Dairy, Oregon to the U.S. Timberland's tree nursery and the muck soil trials received irrigation prior to seeding but did not receive in-season irrigation. At the mineral soil site, the Oregon State University (OSU) elite nurseries for soft white (SW), hard white (HW), and hard red (HR) wheat were evaluated. Also at this site, the Western Regional Trials for barley and wheat were conducted and the OSU Statewide Barley and Wheat Trials were evaluated. These Statewide Trials were also conducted at a site on Lower Klamath Lake (LKL) on muck soil. The LKL site also served as the site for the Western Regional Uniform Oat Trial and a screening site for non-replicated early generation material from the OSU barley breeding program. At both sites, yields tended to be lower than those noted in earlier years. The highlight for both sites was the yield potential shown by selected SW wheat lines, especially with no in-season irrigation at the LKL site.

Introduction

Grain production was changed in the 2001 growing season with limited water deliveries to the Klamath Irrigation Project. As would be expected, the most adversely affected fields were those with mineral soils with low water holding capacities. Many of these fields had insufficient soil water to produce grain. Much of the planted small grain acreage was harvested as hay or used for pasture. With the assistance of the Natural Resource Conservation Service (NRCS), which provided cost sharing incentives, over 29,000 acres were seeded to small grains as cover crops to prevent wind erosion. Barley, wheat, and oats were all used in these plantings, but beardless varieties of barley and wheat were more prominent than in the past. Some of the muck soil cover-cropped fields were harvested for grain but most produced hay or were used for pasture.

In the project land serviced by the Tulelake Irrigation District, considerable grain acreage was planted that did receive supplemental irrigation from private and state-funded irrigation wells. Many of the fields that had grown sugarbeets or potatoes during the 2000 growing season were planted to small grains, and these contained residual nitrogen and soil moisture from those previous crops. According to J. W. Cope of Winema Elevators, yields for these fields were just slightly less than expected in a normal year.

Many of the fields at LKL serviced by the Klamath Drainage District received winter pre-irrigation.

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Most of these fields did not receive in-season irrigation, but with the residual moisture in these high water-holding muck soils, grain was produced. Barley yields were less than in some years, but with less weed pressure and no barley stripe rust, pesticide costs were reduced. Some yields of white wheat from this area were similar to or increased over previous years. These results indicate definite advantages for the winter flooding practice.

In previous years, small grain variety trials were conducted on-site at KES on a mineral soil and at a LKL site on a silty clay loam muck soil. These trials received in-season irrigation either from solid-set or linear sprinklers. With the lack of water at KES, the mineral soil trials were moved to the U.S. Timberland's nursery site west of Dairy, Oregon. These trials were conducted under solid-set sprinkler irrigation. The trials at the LKL site received winter flooding but no in-season irrigation.

On the mineral soil site, OSU Elite Nurseries for HR, SW, and HW wheat types were conducted. Western Regional Trials with barley and hard and soft wheat, and OSU Statewide Trials with barley and hard and soft wheat were also conducted. At the muck soil site a non-replicated OSU barley breeding trial, Western Regional Uniform Oat Trial, and OSU Statewide Trials with barley and hard and soft wheat were conducted.

Procedures

Mineral Soil Trials

The spring grain variety trials were conducted on a Fordney loamy fine sand. For the previous 2 years, this field was used to grow a conifer crop and received methyl- bromide fumigation prior to seeding of the conifers. All trials were arranged in a randomized block design. The Western Regional Trials included four replicates, while OSU Elite Wheat Nurseries and Statewide Trials included three replicates. Seed was planted at a 1-in depth at 30 seeds/ft^2 with a Kincaid (Kincaid Equipment Manufacturing) plot planter on May 7 and 8. Plots were 4.5 ft wide (9 rows at 6-in spacing) and 20 ft long. Before harvest, a 5.5-ft border between the plots was shredded, resulting in 14.5- by 4.5-ft harvest areas.

All plots were fertilized with 50 lb N, 63 lb P_2O_5, and 41 lb S/acre banded at planting (16-20-0-13 at 310 lb/acre) and 50 lb N applied as URAN (32 percent N) solution in the irrigation water on June 19. Due to reduced weed pressure from the fumigation and long-term weed control efforts at the nursery site, no herbicide treatments were necessary. Irrigation was applied with solid-set sprinklers arranged in a 30- by 40-ft pattern. From establishment to head filling, 12.6 in of irrigation and 1.9 in of rainfall was received on the plots. This was about 75 percent of the calculated AgriMet evapotranspiration for grain for this period.

During the growing season, the date to achieve 50 percent heading was noted and just prior to harvest, plant height and lodging percentages were recorded. Between August 27 and 31 grain was harvested with a Hege (Hans-Ulrich Hege) plot harvester with a 4.5-ft-wide header.

Test weights were determined for one replication in the OSU Elite Wheat Nurseries and the Western Regional wheat and barley trials. Percent plumps and thins were determined for one replication of the Western Regional Spring Barley Nursery. Percent protein was determined in Corvallis for the OSU

Statewide soft wheat trial. Data were analyzed with SAS software.

Muck Soil Trials

The trials were conducted on an Algoma silt loam soil that received winter flood pre-irrigation in a continuous grain rotation. Grain was planted with a Kincaid plot planter on May 28. Seed was placed at 2-in depth into moisture at a seeding rate of 30 seeds/ft^2. Fertilizer included 70 lb N/acre shanked in before planting as anhydrous ammonia and 50 lb N, 63 lb P_2O_5, and 41 lb S/acre banded at planting (16-20-0-13 at 310 lb/acre). With no in-season irrigation to wet the soil surface, weed emergence after planting was minimal resulting in no herbicide application being necessary. Also with dry growing conditions throughout the summer, no barley stripe rust was present and no foliar fungicide treatments were applied.

During the growing season, the date to achieve 50 percent heading was noted and just prior to harvest, plant height and lodging percentages were recorded. Grain was harvested and yield recorded on September 20 with a Hege (Hans-Ulrich Hege) plot combine with a 4.5-ft-wide header. Test weights were determined for one replication in the Uniform Northwest Oat Trial. Percent protein was determined in Corvallis for the OSU Statewide Trials. Data were analyzed with SAS software.

Results and Discussion

For a grain variety to be considered superior for the Klamath Basin, it must show improvements over standard varieties over time. This ensures producers that it has the potential to produce favorably in seasons with variable climatic conditions. In the past, with a continuing history of trials on-site at KES or LKL, average tables were produced over time to show this multiple year potential. However, with the new mineral soil site and the lack of customary in-season irrigation for the muck soil site, the validity of making multiple year averages was questioned. Thus the data presented in this report are those produced only during the 2001 growing season.

Barley

Western Regional Spring Barley Nursery (Mineral Soil)

Fourteen standard varieties and 26 numbered selections were included in the 2001 nursery. Yields in this trial ranged from 3,450 to 5,500 lb/acre and averaged 4,430 lb/acre (Table 1). These yields were less than those in the 2000 trial, where an average yield of 5,730 lb/acre was observed. Seventeen of these lines yielded over 4,600 lb/acre and did not significantly differ from the highest yielding line, WA8682-96 (5,500 lb/acre), which is being evaluated for malting. The highest yielding feed barley was WA8709-96 (5,450 lb/acre). Other feed-type numbered selections in the top-yielding group included WA10147-96 (5,070 lb/acre), BZ594-20 (4,860 lb/acre), UT004087 (4,740 lb/acre), and MT960228 (4,700 lb/acre). The potential experimental malting barleys included in the highest yield group were MT960099 (5,140 lb/acre), WA10138-96 (5,070 lb/acre), 2B97-4299 (4,900 lb/acre), 95SR316A (4,840 lb/acre), 95SR149C (4,730 lb/acre), and 2B96-5057 (4,620 lb/acre). Named varieties in this top-yielding group included Baronesse (5,170 lb/acre), CDC Helgason (4,980 lb/acre), CDC Bold (4,710 lb/acre), Legacy (4,690 lb/acre), and Harrington (4,640 lb/acre). The top three of these named varieties are feed types and

Legacy and Harrington are malting barleys.

Test weights for this trial ranged from 50.0 to 57.0 lb/bu with an average across all entries at 53.9 lb/bu. This was similar to the 2000 trial where the average test weight was 54.4 lb/bu. Percent plumps, those grains remaining above the 6/64-in screen, averaged 90.9 percent. This was slightly less than the 95.0 percent average observed in 2000. One entry in the 2001 test, 95Ab5180, contained only 46.7 percent plumps.

OSU Statewide Spring Barley Trial (Mineral Soil)

Twelve standard varieties and seven numbered selections were included in this trial. Yields ranged from 3,410 to 5,700 lb/acre and averaged 4,760 lb/acre (Table 2). The average yield across entries in 2001 was less than the average yield (5,940 lb/acre) obtained in the 2000 trial. Fourteen of these lines yielded at least 4,690 lb/acre and did not significantly differ from the highest yielding variety, Bancroft (5,700 lb/acre), a malt barley. Top-yielding numbered lines were YU597-399 and WA8682-96 (5,350 lb/acre). Both of these lines are being evaluated for use in malting. WA8682-96 was also the highest yielding line in the Western Regional Trial reported above. The highest feed-type numbered line was H3860224 (5,240 lb/acre). High-yielding standards included the malting types Valier (5,390 lb/acre), Chinook (5,190 lb/acre), Harrington (4,860 lb/acre), Garnet (4,830 lb/acre), and Othello (4,810 lb/acre). Standard feed-types in the top yielding group included Xena (5,260 lb/acre), Farmington (5,050 lb/acre), and Steptoe (4,690 lb/acre).

OSU Statewide Spring Barley Trial (Muck Soil)

This trial included the same entries as the mineral soil site trial. Yields in this trial ranged from 1,330 to 4,250 lb/acre and averaged 3,100 lb/acre (Table 3), less than the 2000 trial average of 5,340 lb/acre. Also, the average yield for this muck soil site with no in-season irrigation was less than for the mineral soil site (4,760 lb/acre). At this site, five lines yielded at least 3,480 lb/acre and did not significantly differ from the highest yielding variety, Valier (4,250 lb/acre), a feed type barley. This group of five included three lines being evaluated for malting quality: WA8682-96 (4,140 lb/acre), YU597-390 (3,830 lb/acre), and Othello (3,820 lb/acre), and the feed-type Farmington (3,480 lb/acre). Of these five, all except YU597-390 were in the mineral soil top-yielding group.

One line in the test, Stab-7, was very slow in tillering and head formation, as was evident in the low yield (1,330 lb/acre) for this line. This variety, which has been tested as a winter barley, possibly did not receive a proper vernalization period to stimulate heading. However, heading inhibition did not occur with the line on the mineral soil.

Test weights for this trial ranged from 50.4 to 54.8 lb/bu with an average of 53.2 lb/bu. This was similar to the test weight average of 53.9 lb/bu in the Western Regional Barley Trial conducted on mineral soils. It was speculated that the lack of in-season irrigation water might lower test weights, but this did not appear to happen. Protein content for the trial entries ranged from 12.6 to 15.4 percent. This resulted in all entries having higher protein concentrations than the accepted maximum level of 12.5 percent for malting varieties. This was expected considering that standard N rates were applied and yields were about 60 percent of normal.

Wheat

OSU Elite Soft White Spring Wheat Nursery (Mineral Soil)

Six named varieties and 24 numbered lines were included in the trial. Yields ranged from 3,770 to 5,720 lb/acre with an average of 4,650 lb/acre (Table 4), less than the average yield (6,420 lb/acre) that was achieved in the 2000 trial at KES. Fourteen top-yielding lines produced at least 4,690 lb/acre. WS-1 (5,720 lb/acre), Alpowa (4,980 lb/acre), Dirkwin (4,890 lb/acre), and Penewawa (4,700 lb/acre) were the standard varieties in this top-yielding group. High-yielding numbered lines in the group included OR9640085 (5,390 lb/acre), OR4970062, (5,340 lb/acre), and OR4200010 (5,310 lb/acre). Test weights for the trial ranged from 59.0 to 65.5 lb/bu with an average of 63.3 lb/bu.

OSU Elite Hard White Spring Wheat Nursery (Mineral Soil)

One named variety and 35 numbered lines were included in the trial. Yields ranged from 3,180 to 5,110 lb/acre with an average of 4,220 lb/acre (Table 5), less than the average yield (5,130 lb/acre) achieved in the 2000 trial at KES. Eleven top-yielding lines produced at least 4,490 lb/acre. Lolo (5,100 lb/acre), a newly released line from the Idaho program, was in this group of high-yield producers. High-yielding numbered lines included OR4910006 (5,110 lb/acre), OR4990092 (4,760 lb/acre), and OR942834 (4,750 lb/acre). OR4910006 and OR942834 were both in the highest yielding group in the 2000 trial as well. Test weights ranged from 60.0 to 69.0 lb/bu and averaged 65.1 lb/bu.

OSU Elite Hard Red Spring Wheat Nursery (Mineral Soil)

One named variety and 22 numbered lines were included in the trial. Yields ranged from 3,270 to 4,420 lb/acre with an average of 3,940 lb/acre (Table 6), less than the average yield (5,210 lb/acre) achieved in this trial in 2000. Thirteen high-yielding lines yielded at least 3,960 lb/acre. Tara (3,960 lb/acre), a newly released line from the Washington State program, was among the high-yield producers. High-yielding numbered lines included OR4870148 (4,420 lb/acre), OR3900362 (4,400 lb/acre), and OR4870410 (4,340 lb/acre). OR4870410 was also in the highest yielding group in 2000. Test weights ranged from 62.5 to 67.5 lb/bu and averaged 64.5 lb/bu.

Western Regional Soft White Spring Wheat Nursery (Mineral Soil)

Four standard varieties and 11 numbered selections were included in the 2001 nursery. Yields ranged from 5,000 to 2,800 to lb/acre and averaged 4,140 lb/acre (Table 7). Yields averaged 65 percent of those observed in the 2000 trial, where average yield was 6,410 lb/acre. Seven lines yielding at least 4,480 lb/acre did not significantly differ from the highest yielding line, Alpowa (5,000 lb/acre). Penawawa (4,660 lb/acre), another standard, also was among the highest yielding lines. Numbered lines in this top-yielding group included IDO564 (4,740 lb/acre), WA007877 (4,560 lb/acre), ML037C-6-2 (4,540 lb/acre), OR942889 (4,480 lb/acre), and WA007884 (4,480 lb/acre). OR942889 was also a top-yielding line in the OSU Elite Soft White Spring Nursery this year. Test weights for this trial ranged from 61.0 to 66.0 lb/bu with an average across all entries of 64.6 lb/bu.

Western Regional Hard Spring Wheat Nursery (Mineral Soil)

This trial evaluated both HW and HR lines. Two standard HW varieties and 8 numbered HW selections and 2 standard HR varieties and 16 numbered HR lines were evaluated (Table 8). Yields for the HW lines in this trial ranged from 3,380 to 5,280 lb/acre and averaged 4,450 lb/acre. HR yields ranged from 3,610 to 4,540 lb/acre and averaged 4,090 lb/acre. Across all of the HW and HR lines, yields averaged 4,220 lb/acre. In the 2000 trial, average yields were higher for both types of wheat with HW types averaging 6,450 lb/acre and HR types averaging 5,730 lb/acre.

For the HW types in 2001, three lines yielded at least 5,100 lb/acre and were not significantly different from each other. These were the numbered lines OR4920311 (5,280 lb/acre) and WA007901 (5,100 lb/acre) and the standard IDO 377S (5,170 lb/acre). OR4920311 yielded significantly more than did any of the HR selections.

For the HR lines, 12 entries yielded at least 3,920 lb/acre and did not differ in yield. The standard, Westbred 926 (3,960 lb/acre) was in this group, but was second lowest in yield among these lines. Numbered lines in the group included N96-0060 (4,540 lb/acre), IDO545 (4,470 lb/acre), and IDO557 (4,370 lb/acre). N96-0060 produced the highest yield among HR entries in the 2000 trial at KES.

Test weights for both types ranged from 62.5 to 68.0 lb/bu. The grand mean for both types was 64.6 lb/bu. A trend was seen for the average test weight across the HW lines (65.7 lb/bu) to be greater than for HR lines (64.0 lb/bu).

OSU Statewide Soft Spring Wheat Nursery (Mineral Soil)

This trial was conducted at both the mineral and muck soil sites. It evaluated eight standard SW lines and three numbered selections. In addition, Alpowa was tested with no seed treatment, with fungicide seed treatment only, and with both fungicide and insecticide seed treatments. Jefferson, a HR type, Winsome, a HW type, and three oat varieties were included in the trials for comparison.

Not considering the untreated Alpowa, there were no significant yield differences among the SW lines. The yield range from 4,190 to 5,420 lb/acre was within the least significant difference of 1,260 lb/acre for the trial (Table 9). Average yield of the SW lines (4,820 lb/acre) was less than the average in the 2000 trial (5,900 lb/acre). Treasure (5,420 lb/acre) and Challis (5,400 lb/acre) were numerically the highest yielding standard varieties. Treasure was also the highest yielding entry in the 2000 Statewide Spring Wheat Trial. WA7902 (5,010 lb/acre) and WA7884 (4,960 lb/acre) were numerically the highest yielding experimental lines. WA7884 also yielded well in the Western Regional Soft White Nursery. There were yield advantages for fungicide (5,120 lb/acre) and fungicide/insecticide (4,420 lb/acre) seed treatments over untreated (3,360 lb/acre) Alpowa. Ten SW lines exhibited increased yields over the HR line, Jefferson (3,610 lb/acre). The HW line, Winsome (4,330 lb/acre), was equivalent in yield to the SW lines. Two of the SW lines, Treasure and Challis, had higher yields than the highest yielding oat selection, Cayuse (4,030 lb/acre).

For the SW lines, test weights ranged from 61.1 to 63.3 lb/bu and averaged 62.5 lb/bu. Test weights for the fungicide-treated Alpowa, WA7884, and Wawawai were greater than that for Challis.

Protein contents within the SW lines were similar to Winsome, the HW line. Jefferson, a HR type, and all oat selections exhibited higher protein content than all SW wheat selections.

The oat selections included Cayuse, a hulled variety, and hull-less varieties Lamont and Provena. As harvested, yields for Cayuse (4,030 lb/acre) and Lamont (3,390 lb/acre) were not different, with both of them yielding more than Provena (2,780 lb/acre). Test weights for the two hull-less lines were over 10 lb/bu more than the hulled line. Most of this difference was due to the lack of the low-density hull. Considering protein content, Provena (16.1 percent) was greater than Lamont (13.9 percent) and both hull-less lines were greater than Cayuse (10.7 percent). From the literature, oat grain will account for about 75 percent of the weight in a hulled variety. Using this value and calculating yield and protein content for Cayuse (3,020 lb/acre calculated) resulted in no yield differences for the three lines. Protein content for Cayuse (14.3 percent calculated) is between the two hull-less lines.

OSU Statewide Soft Spring Wheat Nursery (Muck Soil)

Unlike the mineral site, differences in yields were present within the SW types. Yields ranged from 3,180 to 5,700 lb/acre and averaged 4,250 lb/acre (Table 10). The average for the muck soil site was less than in the mineral soil (4,820 lb/acre) and the 2000 trial (5,690 lb/acre). WA7884 (5,700 lb/acre) and Alpowa (5,100 lb/acre, fungicide/insecticide; 4,920 lb/acre, untreated; 4,740 lb/acre, fungicide) were the top-yielding selections. These selections yielded more than the HR and oat entries. Winsome, a HW type, produced similar yield to these highest yielding SW types.

For the SW lines, test weights ranged from 59.8 to 63.2 lb/bu and averaged 62.0 lb/bu. WA7902 and Wawawai had slightly lower test weights compared to the other SW types. With the lack of in-season irrigation, especially during grain filling, speculation that test weights might be lower for these wheat lines proved false. Grand means across all entries in the trials were 59.6 for the muck soil and 60.0 for the mineral soil.

Numerically, the lowest yielding SW lines, Wawawai and WA7902, exhibited the highest protein contents. As at the mineral soil site, overall SW protein contents were similar to the HW selection and lower than in the HR line and oat selections. In the muck soil, wheat entries exhibited 0.7 to 3.2 percent more protein than on the mineral soil. Protein content of oats was higher by 5.1 to 7.9 percent. Lower yields on the muck soil, a slightly increased N fertilizer rate, and mineralized nitrogen from organic matter all would account for an increase in available N and thus higher protein levels.

As with oat selections in the mineral soil, calculating values to account for the hulls of Cayuse (2,840 lb/acre calculated) results in no observed grain yield differences. Protein content rankings were also the same with Provena (24.0 percent) being greater than Cayuse (21.1 percent calculated), which was greater than Lamont (19.7percent).

OSU Statewide Hard Spring Wheat Nursery (Mineral Soil)

This trial was conducted on both mineral and muck soils. It evaluated four standard HW lines, four numbered HW selections, seven standard HR varieties, and three numbered HR lines. In addition, the HW variety, Winsome, was tested at seeding rates of 20, 30, and 40 seeds/ft^2. Penawawa and Alpowa, SW lines, were included for comparisons in the trial.

For the HW entries, 9 of the 10 selections were shown to be similar to each other. For the HW types, yield ranged from 4,340 to 5,490 lb/acre with an average yield of 4,810 lb/acre (Table 11). IDO 377S (5,490 lb/acre), Lolo (5,380 lb/acre), Winsome (5,180 lb/acre), and WA7901 (5,120 lb/acre) numerically were the highest yielding lines. All three seeding rates for Winsome produced statistically equivalent yields. Winsome and IDO 377S were the highest yielding HW lines in the 2000 trial at KES.

Yields for the HR selections ranged from 3,780 to 4,890 lb/acre and averaged 4,370 lb/acre (Table 11). Five of the HR entries were in the highest yielding group. These included the standard varieties Jefferson (4,890 lb/acre) and Scarlet (4,540 lb/acre). Also in this highest yielding group were the numbered lines WA7839 (4,630 lb/acre), OR4910028 (4,570 lb/acre), and IDO557 (4,520 lb/acre). IDO557 was also in the highest yielding group in the Western Regional Hard Spring Wheat Nursery.

The two SW entries, Penawawa (4,910 lb/acre) and Alpowa (4,730 lb/acre), produced yields similar to the highest producing HW and HR lines. Unfortunately, samples from this trial were inadvertently discarded at Corvallis before test weight and protein contents were determined.

OSU Statewide Hard Spring Wheat Nursery (Muck Soil)

In the muck soil, the two highest yielding selections were the SW variety, Alpowa (5,940 lb/acre), and the HW variety Winsome (5,040 lb/acre) (Table 12). Other HW selections that were equivalent to Winsome were IDO560 (4,200 lb/acre) and Lolo (4,080 lb/acre). HR line yields were slightly reduced from those of the top-yielding group of the other types. Eight of the HR selections were similar and included Jefferson (4,200 lb/acre), Scarlet (4,140 lb/acre), Hank (4,080 lb/acre), and OR4910028 (3,780 lb/acre). Numerically, Hank and Alpowa produced more grain on the muck soil than on the mineral soil. This was not the case with any of the other trial entries.

Means for the test weights were slightly higher than 60 lb/bu. None of the selections were below the 58 lb/bu minimum for Grade 1 wheat. Protein contents for both the HW and the HR entries tended to increase with decreasing yields. All of the HR lines produced grain with at least 14 percent protein, which would result in a premium payment. HR line protein was greater than for either HW or SW lines.

Oats

Western Regional Uniform Northwestern Spring Oat Nursery (Muck Soil)

Twelve standard varieties and 18 numbered selections were included in the 2001 nursery. Yields in this trial ranged from 2,890 to 5,570 lb/acre and averaged 4,260 lb/acre (Table 13). These yields were 71 percent of the 2000 trial average yield of 5,960 lb/acre. Ten lines yielded at least 4,530 lb/acre and did not significantly differ from the highest yielding lines, OT382 and 95Ab10854 (5,570 lb/acre). Other numbered lines included in this top-yielding group included 95Ab12584 (4,800 lb/acre), AbSP9-2 (4,550 lb/acre), and 90Ab1322 (4,530 lb/acre). Standard varieties in this highest yielding group included CDC Pacer (5,200 lb/acre), Celsia (5,010 lb/acre), Derby (4,870 lb/acre), and Killdeer (4,810 lb/acre).

Test weights ranged from 39.0 to 43.0 lb/bu and averaged 40.6 lb/bu. This was similar to the average (40.4 lb/bu) noted in 2000 when the trial was conducted at KES on a mineral soil with solid-set irrigation.

Summary

Promising new lines of grain were noted in all types and classes in these trials. Selections of barley to be used for malting include WA8682-96, YU597-399, and YU597-390. Yields and percent plumps were favorable for these lines. However, differing nitrogen management strategies need to be considered because protein levels were excessive for use in malting. Promising feed barley lines include WA8709-96 and H3860224. All of these lines should be evaluated for susceptibility to barley stripe rust. Although not a problem this year, under the right environmental conditions this disease has the potential to adversely affect Klamath Basin barley production.

Overall, the high yield for SW wheat in the muck soil with winter pre-irrigation was the highlight of these trials. As always there is the concern that late spring frosts will injure wheat more than barley, but the production levels achieved by SW varieties without in-season irrigation are promising.

New wheat lines exhibited good potential. For SW types, OR9640085, OR4970062, OR4200010, WA7902, WA7884, IDO564, WA7877, ML037C-6-2, and OR942889 produced high yield. HW types yielded as well as SW lines in certain trials. Potential was shown for some of these types, including OR4910006, OR4990092, OR942834, OR4920311, WA007901, IDO560, and WA7899. HR types did not reach the 14 percent protein content necessary for the premium grade except in tests on the muck soil. New HR lines that indicated good potential were OR4870148, OR3900362, OR4870410, N96-0060, IDO545, IDO557, WA7839, and OR4910028.

For oats, the hull-less lines tested yielded less than the hulled types. However, adjusting for the weight of the hull resulted in these entries being similar in yield to the hulled comparison. Provena, with its higher protein content, was the most interesting hull-less oat. Promising new oat lines from the regional test included OT382, 95Ab10854, 95Ab12584, AbSP9-2, and 90Ab1322.

Table 1. Western Regional Spring Barley Nursery: agronomic and grain quality data for spring barley varieties and lines established on May 7, 2001, at U.S. Timberland's tree nursery, Dairy, OR.

Variety or line	Row	use[1]	Yield	Test weight	% Above screen 6/64	5.5/64	Pan	Height	50% head
			lb/acre	lb/bu	-------percent-------			in	Julian
WA8682-96	2	f/m	5500 a[2]	56.0	94.6	3.8	1.5	25	183
WA8709-96	2	f	5450 a	56.5	96.7	2.5	0.8	25	183
Baronesse	2	f	5170 ab	54.0	91.3	6.1	2.6	26	184
MT960099	2	f/m	5140 ab	55.5	85.1	10.6	4.4	23	183
WA10147-96	2	f	5070 ab	53.5	93.3	5.1	1.6	25	184
WA10138-96	2	m	5070 ab	54.5	92.1	5.5	2.4	25	181
CDC Helgason (TR346)	2	f	4980 abc	54.5	91.5	6.6	1.9	27	185
2B97-4299	2	m	4900 abcd	54.0	90.8	6.6	2.6	28	184
BZ594-20	2	f	4860 abcd	55.0	90.5	6.3	3.2	25	183
95SR316A	2	m	4840 abcd	56.0	87.8	8.4	3.8	27	185
UT004087	6	f	4740 abcde	55.0	94.0	4.5	1.6	28	180
95SR149C	2	m	4730 abcde	53.5	94.0	4.6	1.4	27	185
CDC Bold	2	f	4710 abcde	53.5	86.9	9.9	3.2	25	184
MT960228	2	f	4700 abcde	56.0	92.3	5.6	2.0	25	184
Legacy (6B93-2978)	6	m	4690 abcde	52.0	96.7	2.5	0.8	33	183
Harrington	2	m	4640 abcdef	55.0	90.7	7.3	2.0	27	185
2B96-5057	2	m	4620 abcdef	54.1	93.9	4.5	1.6	27	185
UT004467	6	f	4520 bcdefg	52.0	83.1	12.0	4.9	27	178
CDC Select	2	m	4510 bcdefg	54.0	95.6	3.4	0.9	26	183
UT001632	6	f	4480 bcdefgh	55.0	97.4	1.8	0.8	29	179
BZ596-117	2	f	4410 bcdefgh	55.0	88.6	8.2	3.2	23	183
Steptoe	6	f	4400 bcdefgh	52.5	95.4	3.3	1.4	24	180
2B97-4077	2	m	4350 bcdefghi	53.0	87.8	9.5	2.7	28	185
93Ab688	6	f	4330 bcdefghi	52.0	90.9	6.5	2.6	25	179
CDC Copeland (TR150)	2	m	4320 bcdefghi	53.0	95.2	3.5	1.3	28	185
PB1-97-2R-7090	2	f	4310 bcdefghi	57.0	92.2	5.5	2.3	25	183
PB1-95-2R-517	2	f	4310 bcdefghi	56.5	90.4	7.1	2.5	23	183
MT970116	2	f/m	4280 bcdefghi	55.0	92.8	5.2	2.1	27	183
UT003757	6	f	4150 cdefghi	50.0	82.6	12.5	4.8	25	179
6B95-2482	6	m	4120 cdefghi	53.5	92.5	5.9	1.6	29	180
TR 167	2	m	4030 defghi	54.5	96.3	2.6	1.1	25	183
Drummond (ND15477)	6	m	3920 efghi	52.0	95.5	3.4	1.1	27	180
Stander	6	m	3750 fghi	54.0	93.9	4.5	1.6	27	183
PB1-95-2R-A629	2	f	3680 ghi	54.0	94.5	4.1	1.4	24	181
95Ab5180	6	m	3680 ghi	50.0	46.7	36.5	16.7	25	180
6B95-2089	6	m	3650 ghi	54.0	92.6	6.0	1.4	30	181
ND15422	6	m	3650 ghi	50.5	95.2	3.7	1.1	27	182
BCD 47 (OR2967102)	2	m	3590 hi	53.0	89.1	8.8	2.1	22	183
Morex	6	m	3490 i	52.0	92.0	5.8	2.2	28	180
Sprinter	2	f	3450 i	53.0	92.8	5.6	1.6	21	185
Mean			4430	53.9	90.9	6.6	2.5	26	182
CV (%)			15	--	--	--	--	7	1
LSD (0.05)			910	--	--	--	--	3	1

[1]Use: f = feed, m = malt, f/m = being evaluated for malting.
[2]Values within a column followed by the same letter are not significantly different (p = 0.05).

Table 2. OSU Statewide Spring Barley Trial: mineral soil, agronomic and grain quality data for spring barley varieties and lines established on May 7, 2001, at U.S. Timberland's tree nursery, Dairy, OR.

Variety or line[1]	Row	Use[2]	Yield	Height	50% head
			lb/acre	in	Julian
Bancroft	2	m	5700 a[3]	26	185
Valier	2	f	5390 ab	26	184
YU597-399	2	f/m	5350 ab	20	183
WA8682-96	6	f/m	5350 ab	25	183
Xena	2	f	5260 abc	24	184
H3860224	2	f	5240 abcd	26	183
Chinook	2	m	5190 abcde	26	185
Farmington (WA 9504-94)	2	f	5050 abcde	23	185
DA587-124	6	f/m	4910 abcde	20	179
Harrington	2	m	4860 abcdef	23	183
Garnet	2	m	4830 abcdef	24	184
Othello (BCD-47)	2	f/m	4810 abcdef	20	183
Stab-7	6	f/m	4760 abcdef	30	187
Steptoe	6	f	4690 abcdef	23	178
YU597-390	2	f/m	4320 bcdefg	20	183
Stab-113	6	f/m	4130 cdefg	26	183
Morex	6	m	4110 defg	30	180
Orca	2	f	4090 efg	28	181
Stab-47	6	f/m	3750 fg	26	177
Tango	6	f	3410 g	24	178
Mean			4760	25	182
CV (%)			14	7	1
LSD (0.05)			1140	3	1

[1]All seed was treated with fungicide and insecticide (Gaucho) unless otherwise noted.
[2]Use: f = feed, m = malt, f/m = being evaluated for malting.
[3]Values within a column followed by the same letter are not significantly different (p = 0.05).

Table 3. OSU Statewide Spring Barley Trial: muck soil, agronomic and grain quality data for spring barley varieties and lines established on May 28, 2001, at Lower Klamath Lake, Klamath County, OR.

Variety or line[1]	Row	Use[2]	Yield[3]		Test weight	Protein	Height	50% head
			lb/acre		lb/bu	%	in	Julian
Valier	2	f	4250	a[4]	54.6	14.4	23	199
WA8682-96	6	f/m	4140	ab	54.7	13.4	25	195
YU597-390	2	f/m	3830	abc	53.6	14.6	20	193
Othello (BCD-47)	2	f/m	3820	abc	54.0	15.3	20	194
Farmington (WA 9504-94)	2	f	3480	abcd	53.0	14.5	24	200
TR167	2	f/m	3440	bcde	54.5	14.4	26	199
Orca	2	f	3420	bcde	54.5	14.8	24	192
DA587-124	6	f/m	3340	cdef	53.6	13.3	20	193
H3860224	2	f	3320	cdef	54.4	15.1	24	197
Xena	2	f	3310	cdef	53.1	13.4	23	197
Harrington	2	m	3310	cdef	53.7	14.4	23	200
Bancroft	2	m	3240	cdef	53.9	14.5	25	201
YU597-399	2	f/m	3190	cdef	54.4	14.8	20	197
Morex	6	m	3120	cdefg	52.9	14.3	31	196
Stab-47	6	f/m	2930	defg	51.4	15.0	28	193
CDC Select	2	m	2860	defgh	54.8	14.9	25	200
Stab-113	6	f/m	2800	defgh	51.7	15.1	27	201
Samish-23	2	f/m	2760	defgh	53.2	14.7	24	200
Steptoe	6	f	2730	defgh	50.9	13.2	22	193
Chinook	2	m	2660	efgh	53.4	15.4	23	200
Jersey	2	f	2630	fgh	52.1	15.1	24	201
Tango	6	f	2390	gh	50.4	12.6	24	193
Garnet	2	m	2090	hi	52.6	15.4	22	203
Stab-7	6	f/m	1330	i	51.4	15.3	27	NA
Mean			3100		53.2	14.4	24	197
CV (%)			15		1	4	7	1
LSD (0.05)			780		1.0	0.9	3	2

[1]All seed was treated with fungicide and insecticide (Gaucho) unless otherwise noted.
[2]Use: f = feed, m = malt, f/m = being evaluated for malting.
[3]Yield normalized to 10 percent moisture.
[4]Values within a column followed by the same letter are not significantly different (p = 0.05).

Table 4. OSU Elite Soft White Spring Wheat Nursery: agronomic and grain quality data for spring wheat varieties and lines established on May 7, 2001, at U.S. Timberland's tree nursery, Dairy, OR.

Variety or line	Yield	Test weight	Height	50% head
	lb/acre	lb/bu	in	Julian
WS-1	5720 a[1]	63.0	31	185
OR9640085	5390 ab	63.0	32	184
OR4970062	5340 abc	64.0	31	182
OR4200010	5310 abc	63.5	35	188
OR942845	5230 abcd	63.5	31	184
OR4200018	5200 abcde	63.0	31	189
Alpowa	4980 abcdef	64.5	30	183
OR4850001	4910 abcdef	62.0	29	186
Dirkwin	4890 abcdef	63.0	29	184
WA007831	4890 abcdef	63.5	29	184
OR942838	4870 abcdef	64.5	30	186
ID000488	4810 abcdefg	63.0	33	186
Penewawa	4700 abcdefgh	65.0	29	183
OR942889	4690 abcdefgh	64.0	31	184
OR4970039	4590 bcdefgh	64.5	28	183
OR4200012	4590 bcdefgh	62.0	36	186
Pomerelle	4580 bcdefgh	63.0	25	184
Whitebird	4580 bcdefgh	64.0	28	184
OR4880013	4450 bcdefgh	61.5	31	189
OR4990007	4410 bcdefgh	65.5	30	182
OR4200014	4410 bcdefgh	63.0	33	189
OR4200008	4360 cdefgh	64.5	28	188
OR4200017	4290 defgh	63.0	31	188
OR4970063	4260 defgh	64.0	27	180
OR4200009	4240 defgh	59.0	32	187
OR4200024	4230 efgh	63.5	29	186
OR4200019	4080 fgh	64.0	32	188
OR4200035	4010 fgh	61.5	28	183
OR4200032	3820 gh	63.5	27	184
OR4200033	3770 h	64.0	29	185
Mean	4650	63.3	30	185
CV (%)	13	--	7	1
LSD (0.05)	1010	--	3	2

[1]Values within a column followed by the same letter are not significantly different ($p = 0.05$).

Table 5. OSU Elite Hard White Spring Wheat Nursery: agronomic and grain quality data for spring wheat varieties and lines established on May 7, 2001, at U.S. Timberland's tree nursery, Dairy, OR.

Variety or line	Yield	Test weight	Height	50% head
	lb/acre	lb/bu	in	Julian
OR4910006	5110 a[1]	66.0	28	182
Lolo (IDO533)	5100 a	66.0	28	183
OR4990092	4760 ab	61.0	30	189
OR942834	4750 ab	66.0	31	182
OR4200037	4690 abc	65.5	25	184
OR4870255	4570 abcd	65.5	28	180
OR4990061	4560 abcde	64.5	28	185
OR4970018	4530 abcde	69.0	28	182
OR4990065	4520 abcde	64.0	28	183
OR4990028	4500 abcde	66.5	27	189
OR4990056	4490 abcde	63.0	26	189
OR4990037	4420 bcdef	64.0	26	183
OR4870453	4410 bcdef	64.5	26	186
OR4920307	4390 bcdefg	63.5	28	186
OR4990062	4360 bcdefg	62.0	25	184
OR4990040	4220 bcdefgh	66.5	26	183
OR4970025	4210 bcdefgh	66.0	27	182
OR4200002	4160 bcdefgh	65.0	29	184
OR4920311	4150 bcdefgh	65.5	29	185
OR3940124	4120 bcdefgh	67.5	25	186
OR4200004	4120 bcdefgh	65.5	29	183
OR4200003	4110 bcdefgh	65.5	30	183
OR4990041	4090 cdefgh	64.5	25	183
OR4990073	4060 cdefgh	65.0	23	184
OR4990009	4010 defgh	64.0	25	183
OR4990088	3960 defgh	65.5	28	182
OR4990080	3930 defgh	65.5	28	181
OR4990014	3930 defgh	67.0	26	184
OR4930230	3930 defgh	64.5	30	188
OR4200001	3910 efgh	63.5	28	189
OR4990089	3820 fghi	65.5	27	185
OR4990032	3780 fghi	65.5	26	185
OR4200034	3770 fghi	66.5	31	183
OR9640151	3760 ghi	67.0	26	180
OR4200021	3680 hi	60.0	30	186
OR4200005	3180 i	66.0	27	180
Mean	4220	65.1	27	184
CV (%)	9	--	6	1
LSD (0.05)	650	--	2	2

[1]Values within a column followed by the same letter are not significantly different (p = 0.05).

Table 6. OSU Elite Hard Red Spring Wheat Nursery: agronomic and grain quality data for spring wheat varieties and lines established on May 7, 2001, at U.S. Timberland's tree nursery, Dairy, OR.

Variety or line	Yield	Test weight	Height	50% head
	lb/acre	lb/bu	in	Julian
OR4870148	4420 a[1]	63.5	28	183
OR3900362	4400 ab	65.0	26	183
OR4870410	4340 abc	63.0	28	182
OR4920002	4280 abcd	65.0	25	185
OR4200036	4190 abcd	63.5	25	185
OR4990118	4180 abcd	64.0	26	184
OR4990119	4130 abcde	62.5	21	182
OR4990126	4120 abcdef	62.5	26	183
OR4990110	4100 abcdef	66.5	25	183
OR4895011	4050 abcdef	64.5	27	182
OR4990111	4030 abcdef	67.0	26	184
OR4990114	4020 abcdef	67.0	25	183
Tara (WA007824)	3960 abcdefg	65.0	29	180
OR4990094	3940 bcdefgh	64.0	23	184
OR4990117	3880 cdefgh	67.5	26	184
OR4890001	3840 defgh	66.0	19	178
OR4990095	3680 efghi	63.5	26	183
OR4990115	3680 efghi	65.0	27	183
OR4930003	3650 fghi	64.0	24	178
OR4910028	3490 ghi	64.0	25	179
OR4870581	3480 ghi	64.0	22	179
OR4880189	3480 hi	63.0	26	183
OR4990123	3270 i	64.5	19	179
Mean	3940	64.5	25	182
CV (%)	7	--	9	1
LSD (0.05)	480	--	4	1

[1]Values within a column followed by the same letter are not significantly different (p = 0.05).

Table 7. Western Regional Soft White Spring Wheat Nursery: agronomic and grain quality data for spring wheat varieties and lines established on May 7, 2001, at U.S. Timberland's tree nursery, Dairy, OR.

Variety or line	Yield	Test weight	Height	50% head
	lb/acre	lb/bu	in	Julian
Alpowa	5000 a[1]	66.0	29	187
IDO564	4740 ab	65.5	29	183
Penawawa	4660 ab	65.0	28	185
WA007877	4560 abc	64.0	28	185
ML037C-6-2	4540 abcd	64.0	26	188
OR942889	4480 abcd	65.0	29	182
WA007884	4480 abcd	65.0	29	187
Rene98	4160 bcde	61.0	32	189
IDO569	4150 bcde	65.5	25	182
WA007902	4020 cde	65.5	24	185
OR9640085	3920 de	65.0	27	181
IDO563	3770 ef	65.5	27	178
WA007883	3590 ef	65.5	27	183
IDO556	3220 fg	65.0	24	185
Federation	2800 g	61.0	37	189
Mean	4140	64.6	28	184
CV (%)	11	--	7	1
LSD (0.05)	620	--	3	1

[1]Values within a column followed by the same letter are not significantly different (p = 0.05).

Table 8. Western Regional Hard Spring Wheat Nursery: agronomic and grain quality data for spring wheat varieties and lines established on May 7, 2001, at U.S. Timberland's tree nursery, Dairy, OR.

Variety or line	Yield	Test weight	Height	50% head
	lb/acre	lb/bu	in	Julian
Hard White Spring				
OR4920311	5280 a[1]	65.0	28	185
IDO 377S	5170 ab	66.5	26	180
WA007901	5100 abc	64.0	28	183
UC1107	4420 def	66.5	25	185
OR4920307	4420 def	63.5	28	186
WA007899	4320 defg	67.0	28	180
IDO560	4260 defgh	65.0	28	184
WA007900	4190 defgh	66.0	28	180
OR4970025	3970 defghi	65.0	27	183
UC 896	3380 i	68.0	23	180
Mean	4450	65.7	27	183
Hard Red Spring				
N96-0060	4540 bcd	65.0	27	182
IDO545	4470 cde	63.0	28	182
IDO557	4370 def	63.5	26	182
IDO558	4290 defg	64.0	25	179
UC1037	4290 defg	64.0	24	180
XKW940W01	4250 defgh	65.0	28	182
WA007875	4210 defgh	64.5	30	180
WA007859	4190 defgh	62.5	31	182
Klasic	4170 defgh	63.0	25	179
98S0191-60-8	4160 defgh	65.0	27	184
KW960175	4110 defgh	63.0	32	183
Westbred 926	3960 defghi	64.0	26	179
MLCB20-123	3920 defghi	63.0	28	180
UC1036	3890 efghi	65.0	22	184
OR4990095	3820 fghi	65.0	27	183
IDO566	3680 ghi	65.0	23	183
N96-2444	3670 ghi	65.0	23	185
N97-0090	3610 hi	63.0	29	183
Mean	4090	64.0	27	182
Grand mean	4220	64.6	27	182
CV (%)	11	--	9	1
LSD (0.05)	650	--	3	2

[1]Values within a column followed by the same letter are not significantly different (p = 0.05).

Table 9. OSU Statewide Soft Spring Wheat Nursery: mineral soil, agronomic and grain quality data for varieties and lines established on May 7, 2001, at U.S. Timberland's tree nursery, Dairy, OR.

Variety or line[1]	Yield[2]	Test weight	Protein	Height	50% head
	lb/acre	lb/bu	%	in	Julian
Soft White Spring					
Treasure	5420 a[3]	62.3	8.4	27	183
Challis	5400 a	61.1	8.5	29	184
Penawawa	5230 ab	62.5	8.8	26	183
Alpowa (fungicide only)	5120 ab	63.3	9.3	30	185
WA7902	5010 ab	62.9	9.5	24	184
Zak	5000 ab	62.6	9.0	29	184
Whitebird	4980 ab	62.6	8.5	27	185
WA7884	4960 ab	63.1	9.5	30	185
Wawawai	4900 ab	63.0	9.7	31	181
IDO526	4680 ab	62.0	8.6	26	183
Alpowa	4420 abc	62.5	9.4	29	186
Jubilee (IDO525)	4190 abc	62.4	9.2	27	185
Alpowa (untreated)	3360 cd	62.4	9.2	30	187
Mean	4820	62.5	9.1	28	184
Hard Red Spring					
Jefferson	3610 cd	63.0	11.1	27	179
Hard White Spring					
Winsome	4330 abc	61.3	9.7	26	186
Oats					
Cayuse	4030 bc	39.5	10.7	28	185
Lamont (hull-less)	3390 c	51.7	13.9	34	191
Provena (hull-less)	2780 d	52.9	16.1	33	191
Mean	3400	48.0	13.5	32	189
Grand mean	4500	60.0	9.9	29	182
CV (%)	17	2	8	9	1
LSD (0.05)	1260	1.8	1.2	3	2

[1]All seed was treated with fungicide and insecticide (Gaucho) unless otherwise noted.
[2]Yield normalized to 10 percent moisture.
[3]Values within a column followed by the same letter are not significantly different (p = 0.05).

Table 10. OSU Statewide Soft Spring Wheat Trial: muck soil, agronomic and grain quality data for varieties and lines established on May 28, 2001, at Lower Klamath Lake, Klamath County, OR.

Variety or line[1]	Yield[2]		Test weight	Protein	Height	50% head
	lb/acre		lb/bu	%	in	Julian
Soft White Wheat						
WA7884	5700	a[3]	61.8	10.2	30	185
Alpowa	5100	ab	63.2	10.8	29	186
Alpowa (untreated)	4920	abc	62.7	10.7	30	187
Alpowa (fungicide only)	4740	abcd	63.1	10.7	30	185
Jubilee (IDO 525)	4620	bcde	61.8	11.6	27	185
Treasure	4320	bcdef	62.1	10.5	27	183
Challis	3960	cdefg	61.9	11.1	29	184
IDO526	3960	cdefg	62.8	11.0	26	183
Zak	3840	defgh	62.4	11.0	29	184
Whitebird	3720	efgh	62.2	11.4	27	185
Penawawa	3600	fghi	61.8	11.4	26	183
WA7902	3600	fghi	60.3	11.9	24	184
Wawawai	3180	ghi	59.8	12.0	32	181
Mean	4250		62.0	11.1	28	184
Hard Red Spring						
Jefferson	3900	defg	63.1	14.3	27	179
Hard White Spring						
Winsome	4740	abcd	62.1	11.4	26	186
Oats						
Cayuse	3780	defgh	40.1	15.8	28	185
Lamont (hull-less)	2880	hi	49.2	19.7	34	191
Provena (hull-less)	2700	i	52.0	24.0	33	191
Mean	3120		47.1	19.8	32	189
Grand mean	4080		59.6	12.7	28	185
CV (%)	15		3	4	6	1
LSD (0.05)	960		2.7	0.6	3	2

[1]All seed was treated with fungicide and insecticide (Gaucho) unless otherwise noted.
[2]Yield normalized to 10 percent moisture.
[3]Values within a column followed by the same letter are not significantly different (p = 0.05).

Table 11. Statewide Hard Spring Wheat Trial: mineral soil, agronomic and grain quality data for varieties and lines established on May 7, 2001, at U.S. Timberland's tree nursery, Dairy, OR.

Variety or line	Yield	Height	50% head
	lb/acre	in	Julian
Hard White Spring			
IDO 377S	5490 a[1]	26	180
Lolo (IDO533)	5380 ab	26	180
Winsome (30 seeds/ft^2)	5180 abc	27	186
WA7901	5120 abcd	29	181
IDO560	4980 abcde	28	184
Winsome (40 seeds/ft^2)	4930 abcde	27	187
WA7899	4760 abcdef	29	180
Winsome (20 seeds/ft^2)	4670 abcdef	27	188
Sunco	4650 abcdef	25	184
WA7900	4340 cdef	28	179
Mean	4810	27	184
Hard Red Spring			
Jefferson	4890 abcde	27	180
WA7839	4630 abcdef	29	179
OR4910028	4570 abcdef	26	179
Scarlet	4540 abcdef	30	181
IDO557	4520 abcdef	29	179
Tara (WA7824)	4360 bcdef	30	179
Iona	4220 cdef	29	182
Westbred 936	4110 def	23	180
Hank	4030 ef	25	178
Yecora Rojo	3780 f	19	178
Mean	4370	27	180
Soft White Spring			
Penawawa	4910 abcde	27	182
Alpowa	4730 abcdef	29	184
Mean	4820	28	183
Grand mean	4670	27	181
CV (%)	13	6	1
LSD (0.05)	1030	3	2

[1]Values within a column followed by the same letter are not significantly different (p = 0.05).

Table 12. Statewide Hard Spring Wheat Trial: organic soil, agronomic and grain quality data for varieties and lines established on May 28, 2001, at Lower Klamath Lake, Klamath County, OR.

Variety or line	Yield[1]	Test weight	Protein	Height	50% head
	lb/acre	lb/bu	%	in	Julian
Hard White Spring					
Winsome (30 seeds/ft^2)	5040 ab[2]	59.7	11.7	26	200
IDO560	4200 bc	60.5	11.3	28	198
Lolo (IDO533)	4080 bcd	60.8	12.4	28	193
WA 7900	3780 cdef	61.0	13.2	26	193
IDO 377S	3720 cdef	61.6	12.4	25	193
WA7899	3660 cdef	61.3	12.1	26	193
Winsome (40 seeds/ft^2)	3480 cdef	59.1	11.6	26	200
Sunco	3360 cdef	60.9	13.1	22	194
Winsome (20 seeds/ft^2)	3180 cdef	58.9	12.2	27	200
WA7901	2640 f	59.5	13.8	28	196
Mean	3740	60.2	12.4	26	196
Hard Red Spring					
Jefferson	4200 bc	60.6	14.6	24	192
Scarlet	4140 bcd	60.2	14.5	29	193
Hank	4080 bcd	60.2	14.8	26	193
OR4910028	3780 cdef	59.1	14.0	24	192
Westbred 936	3180 cdef	60.5	15.3	22	193
Yecora Rojo	3120 cdef	60.2	14.6	18	192
IDO557	3120 cdef	60.6	14.1	25	192
WA7839	3060 cdef	60.4	15.2	27	194
Iona	3000 def	59.9	14.8	30	196
Tara (WA7824)	2880 ef	60.7	15.4	27	192
Mean	3460	60.2	14.7	25	193
Soft White Spring					
Alpowa	5940 a	61.2	11.5	27	194
Penawawa	4140 bcd	60.0	11.6	25	194
Mean	5040	60.6	11.6	26	194
Grand mean	3720	60.2	13.3	26	195
CV (%)	19	1	4	6	1
LSD (0.05)	1140	1.0	0.8	3	2

[1]Yield normalized to 10 percent moisture.
[2]Values within a column followed by the same letter are not significantly different ($p = 0.05$).

Table 13. Uniform Northwestern Spring Oat Nursery: agronomic and grain quality data for spring oats varieties and lines established on May 28, 2001, at Lower Klamath Lake, Klamath County, OR.

Variety or line	Yield	Test weight	Height	50% head
	lb/acre	lb/bu	in	Julian
OT382	5570 a[1]	41.5	35	200
95Ab10854	5570 a	42.0	31	204
CDC Pacer	5200 ab	41.0	36	199
94Ab5543	5020 abc	40.5	32	200
Celsia	5010 abc	39.0	34	201
Derby	4870 abcd	41.5	37	201
Killdeer (ND 930122)	4810 abcde	41.5	31	193
95Ab12584	4800 abcde	39.5	31	193
AbSP9-2	4550 abcdef	42.5	30	199
90Ab1322	4530 abcdef	41.0	27	200
AbSP19-9	4440 bcdef	42.5	28	200
Otana	4410 bcdef	40.5	37	199
90Ab1620	4260 bcdef	41.5	30	202
87Ab5632	4230 bcdef	41.5	31	200
87Ab4983	4170 bcdef	41.0	24	192
Ajay	4100 cdef	39.5	22	200
UC125	4080 cdef	43.0	25	200
91Ab406	4080 cdef	39.0	25	198
Cayuse	3970 cdefg	40.5	31	197
UC129	3900 defg	39.0	29	192
96Ab8796	3840 defg	39.0	26	199
CDC Dancer	3790 defg	42.0	34	200
87Ab5125	3780 defg	41.0	27	199
UC128	3770 defg	38.0	31	193
Whitestone	3750 efg	41.0	32	201
91Ab502	3720 efg	40.0	25	193
AbSP14-6	3620 fg	39.0	27	197
Rio Grande	3600 fg	40.0	25	193
Monida	3560 fg	41.0	31	201
Powell	2890 g	40.0	25	198
Mean	4260	40.6	30	198
CV (%)	18	--	8	1
LSD (0.05)	1100	--	3	2

[1]Values within a column followed by the same letter are not significantly different (p = 0.05).

Cool-season Grass (Timothy and Orchardgrass) Variety Trials

Donald R. Clark and Jim E. Smith[1]

Abstract

Variety trials with orchardgrass and timothy were established in the fall of 2000 at the Klamath Experiment Station (KES), Oregon, and the Intermountain Research and Extension Center (IREC) at Tulelake, California. Yield and forage quality were evaluated from the KES trial while only yield was monitored at IREC. Three cuttings were taken during the 2001 growing season. Due to the lack of surface water for irrigation, harvests at KES were conducted when the stands had depleted the limited soil moisture. Ground and surface water was available through the whole season at IREC. At KES, Clair produced the most consistently high forage yield of the six timothy varieties tested. Concentration of crude protein (CP) for Clair was not in the highest group, but pounds of protein (yield times percent CP) was among the highest. Other high-yielding lines were Barliza, and PXTA-01. Stampede, Quantum, and Latar were consistently high-yielding orchardgrass varieties. Unlike the timothy, the highest yielding variety numerically, Stampede, was also among the highest in CP concentration and lowest in concentrations of acid detergent fiber (ADF) and neutral detergent fiber (NDF). At IREC, Clair and PXTA-01 were among the highest yielding timothy varieties in the two cuttings where significant differences were noted. Only the first cutting in the orchardgrass test produced significant differences and Mammoth, Latar, and Hallmark were in the highest yielding group.

Introduction

Traditionally, alfalfa has been the dominant forage grown for hay in the Klamath Basin. The primary market for Klamath Basin alfalfa is the California dairy industry. Prices range from $100 to $150/ton. Hay from this area, especially for the first and third cuttings, is desired due to its high forage quality, which is achieved because cool growing temperatures cause slow growth and thus short internodes, resulting in high leaf-to-stem ratios. This alfalfa has competition from other hay throughout the West since alfalfa is grown in all climates.

Recently "Other Hay" has commanded a high price. Other hay includes cool-season grasses or grassy alfalfa, a mixture of cool-season grass and alfalfa. Primary markets for other hay are the horse industry, including racehorse businesses and private parties with horses used mainly for recreation. These groups pay high prices for feed for their racing stock or pets. With a regional shortage of hay in 2001, prices for this hay have reached or exceeded $150 to $200/ton. Much of this hay is baled in two-string or small three-string bales that are easy to handle.

Hay produced from quackgrass, tall fescue, annual and perennial ryegrass, orchardgrass, or timothy all are classified as other hay. These species are well adapted to the climate of the

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Klamath Basin, which has an advantage over southern areas of the West where warm temperatures cause these species to be short lived and highly consumptive of irrigation water.

Timothy and orchardgrass are the most desired species for the horse industry. In addition to pure stands of these two species, orchardgrass is the dominant species grown in grassy alfalfa. To learn more about these two grasses and determine viable varieties, four trials were established in the fall of 2000. Two trials were conducted at the Klamath Experiment Station (KES), Oregon, with similar trials established at the Intermountain Research and Extension Center (IREC) at Tulelake, California.

Procedures

Two late-summer seeded, cool-season variety trials were established at KES and IREC. At KES the trials were on a field with Poe fine sandy loam soil that had grown oats for hay earlier in the season. The field was ripped to 12- to 18-in depth in July, followed by moldboard plowing, disking, and harrowing. A Brillion packer was pulled behind the harrow on the last pass to form a smooth, firm seedbed. Prior to seeding, plots received broadcast fertilizer treatments of 50 lb N, 62.5 lb P_2O_5, and 41 lb S/acre (16-20-0-13 at 310 lb/acre). Nitrogen fertilizer applications were also applied early in the 2001 growing season and immediately following the first two harvests. The rate of these N fertilization applications was 50 lb N/acre using URAN (32 percent N) solution. Plots were 4.5 ft wide and 20 ft long. Grass seed was planted at 0.25- to 0.5-in depth at seeding rates of 6 and 12 lb/acre for timothy and orchardgrass, respectively, using a Kincaid (Kincaid Equipment Manufacturing) experimental plot planter on September 1, 2000. Four replications were used in a randomized complete block design for each trial.

At IREC the trials were established in a field with Tulebasin mucky silty clay loam soil. Grass seed was planted at 0.25- to 0.5-in depth at seeding rates of 6 and 12 lb/acre for timothy and orchardgrass, respectively, on September 9, 2000. Broadcast fertilizer applications applied 92 lb N/acre (urea at 200 lb/acre; May 22, 2001), 138 lb N/acre (urea at 300 lb/acre; September 5, 2000), and 16 lb N/acre and 20 lb P_2O_5/acre (16-20-0 at 100 lb/acre; October 9, 2000). Plots were 4.5 ft wide and 20 ft long.

At KES, border strips were planted on either side of the harvested plots. The varieties used in the trials were randomly seeded into these border strips with each variety being represented at least twice. For the first cutting these border strips were not harvested with the harvested plots, but were used to obtain heading data 2 weeks after the first cutting.

Prior to each harvest conducted in the 2001 growing season, 5.5-ft strips were cut between the plots to prevent sample mixing. Forage was harvested with a Carter (Carter Manufacturing Co., Inc.) self-propelled flail harvester with a 3-ft-wide header. At KES, both trials were harvested on May 30, July 5, and September 7. At IREC, the timothy trial was harvested on May 22, July 6, and October 1, and the orchardgrass trial was harvested May 22, July 20, and October 1. Random samples of about 1.0 lb from each plot were oven dried to determine dry matter yield. At KES, dried samples were ground to pass a 2-mm sieve in a Wiley Mill (Arthur H. Thomas Co.) and a 1-mm sieve in a Udy Mill (Udy Corporation). Ground samples were analyzed in a near infrared spectrophotometer (NIRS, NIRSystems) to determine forage quality, including crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) content.

Results and Discussion

At KES, irrigation water from the Klamath Irrigation District was available from July 25 until August 23. Additional irrigation from a sump that collects water from tile drains was applied prior to and after the surface irrigation water. The AgriMet station located at KES recorded total precipitation of 2.1 in from April 1 until the third cutting during the trials. Total irrigation applied was about 18.5 in. These two inputs totaled 20.6 in with the calculated evapotranspiration (ET) for cool-season grasses being 31.8 in. This resulted in about 65 percent of the ET being supplied during these trials. For the first cutting, 1.6 in of rain and 3.6 in of irrigation were recorded. This was about 60 percent of the ET for cool-season grasses. For the second cutting, 0.4 in of rain and 3.2 in of irrigation represented about 25 percent of calculated ET. For the third cutting, 0.1 in of rain and 11.8 in of irrigation were recorded. This was about 120 percent of calculated ET for this period.

At IREC, surface irrigation water was available from July 25 until August 23. Additional water was applied to the plots from a well on-site. The Tulebasin mucky silty clay loam soil can hold close to 5 in of available water per foot of soil. The soil was close to field capacity at the end of the 2000 growing season. Considering the water-holding capacity of this soil along with the precipitation and applied irrigation water, an average of about 90 percent of the calculated ET was available for the forage grasses.

With any perennial forage crop, variety recommendations require results over time to ensure crop performance over the varying climatic conditions encountered by producers. This report provides information for only 1 year; a year that experienced atypical irrigation management at KES. These data will be compiled with data in future years to comprise more complete recommendations.

Timothy

Yields of timothy for each of the three cuttings and total yield at KES are presented in Table 1. Clair was consistently in the highest group in all cuttings and total yield. No other line exhibited this consistent yielding ability. PXTA-04, Barliza, and Timfor yielded in the highest group in three of the four reporting groups. Numerically, Clair was the highest yielding line in the first and third cuttings and the overall total.

With almost full irrigation at IREC, the grand mean yield at this site was nearly double the yields produced at KES. At this site, the only significant differences noted among varieties occurred in the first and second cuttings (Table 2). For the first cutting, Clair, Barliza, and PXTA-01 comprised the highest yielding group. For the second cutting, all of the varieties except Barliza were in the highest yielding group. Numerically, Climax produced the highest total yield even though yield in the first cutting was among the lowest.

Klamath Basin climate inhibits timothy growth to a point where two fully headed harvests are not common. A variety that would head early might overcome this limitation and allow production of higher value headed hay. For the tested varieties, Clair and PXTA-

01 achieved the best maturity at harvest (Table 3). Though only replicated twice, heading data taken 2 weeks after the first cutting mirror those at the first cutting in regard to variety maturity. Early maturity would increase yields and decrease nutritional value, as the stem and seed head will be lower in protein and higher in fibers than vegetative growth or leaves.

Varietal differences were noted in concentrations of CP in the first cutting and of NDF in the first and third cuttings at KES (Table 4). Clair exhibited the lowest CP and highest NDF levels among the varieties. Climax was among the lowest yielding lines, but exhibited high concentrations of CP and low concentrations of NDF. Protein production is the product of yield multiplied by CP content. Because yield differences were greater than differences in CP concentrations, higher yielding varieties produced more pounds of protein than did lower yielding varieties with higher concentrations of CP (Table 5).

Orchardgrass

Yield of orchardgrass for the three cuttings and total yield at KES is presented in Table 6. Three of the varieties, Stampede, Quantum, and Latar, were in the highest yielding group in each of the three cuttings and in total yield. Potomac and Mammoth were in the highest yielding groups except for the second cutting.

Yields at IREC on muck soil with near full irrigation were nearly triple the yields observed at KES (Table 7). The only significant yield difference among the varieties at IREC was noted in the first cutting. For this cutting, Mammoth, Latar, and Hallmark were in the highest yielding group. Quantum produced the highest total yield numerically.

Heading for orchardgrass was delayed compared to timothy. However, there are no price advantages for fully headed orchardgrass hay, as there are with timothy. Maturity of orchardgrass affects yield and nutritive value. Seed maturity differences in orchardgrass varieties will be most critical when the grass is used in mixtures with alfalfa. The selection of an orchardgrass variety that will be in the early heading stage whenever alfalfa is in early bloom will allow maximum yields from both species without compromising stand persistence. For the first cutting and averaged over all cuttings, Mammoth and Hallmark were the most mature varieties (Table 8). Heading differences between varieties were less obvious 2 weeks after the first cutting.

Significant differences in forage quality among varieties were noted with CP in the second cutting and ADF and NDF in the first and third cuttings at KES (Table 9). Stampede, the highest yielding variety, exhibited concentrations of CP in the highest group while the concentrations of ADF and NDF were in the lowest group. Quantum exhibited concentrations of CP in the highest group while the concentrations of ADF and NDF were intermediate. Latar exhibited intermediate concentrations of CP while its concentrations of ADF and NDF were in the lowest group. Stampede, Quantum, and Potomac produced more total pounds of crude protein than Baridana, Hallmark, and Sparta (Table 10). Further evaluation of varieties over years is required to provide recommendations on suitable grasses for grassy alfalfa production under local conditions.

Table 1. Yield of six timothy varieties for each of three cuttings and the total for 2001 at Klamath Experiment Station, Klamath Falls, OR.

Variety	Cutting 1	Cutting 2	Cutting 3	Total
	lb /acre			
Clair	1740 a[1]	1760 ab	2850 a	6360 a
PXTA-04	1320 ab	2290 a	1640 bc	5250 ab
Barliza	1730 a	1870 ab	1530 c	5130 ab
Timfor	1270 ab	1880 ab	1940 bc	5100 ab
PXTA-01	1250 ab	1200 b	2300 ab	4750 b
Climax	970 b	1700 ab	1920 bc	4580 b
Mean	1380	1780	2030	5200
CV (%)	25	30	22	17
LSD (0.05)	530	820	680	1370

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 2. Yield of six timothy varieties for each of three cuttings and the total for 2001 at Intermountain Research and Extension center, Tulelake, CA.

Variety	Cutting 1	Cutting 2	Cutting 3	Total
	lb /acre			
Clair	3800 a[1]	4400 ab	3200	11400
PXTA-04	2200 b	5000 ab	2800	10000
Barliza	3000 ab	4200 b	3400	10600
Timfor	2600 b	5200 ab	3400	11200
PXTA-01	3000 ab	4400 ab	3400	10800
Climax	2200 b	6200 a	3400	11800
Mean	2800	4900	3270	10970
CV (%)	19	24	21	13
LSD (0.05)	800	1800	NS	NS

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 3. Percent heading for six timothy varieties for each of three cuttings, 2 weeks after the first cutting, and the average over cuttings for 2001 at Klamath Experiment station, Klamath Falls, OR.

Variety	Cutting 1	Cutting 1 + 2 Weeks	Cutting 2	Cutting 3	Average
	%				
Clair	18 a[1]	60	6	13 a	12 a
PXTA-04	4 b	35	9	8 ab	7 b
Barliza	5 b	23	6	4 b	5 b
Timfor	1 b	7	8	6 b	5 b
PXTA-01	23 a	60	5	13 a	14 a
Climax	0 b	3	8	7 b	5 b
Mean	8	31	7	8	8
CV (%)	87	---	29	47	28
LSD (0.05)	11	---	NS	6	3

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 4. Crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) of six timothy varieties for each of three cuttings for 2001 at Klamath Experiment Station, Klamath Falls, OR.

Variety	Cutting 1			Cutting 2			Cutting 3		
	CP	ADF	NDF	CP	ADF	NDF	CP	ADF	NDF
	%								
Clair	18.1 c[1]	28.3	48.0 b	23.8	28.6	47.1	16.5	28.3	42.8 b
PXTA-04	20.2 ab	26.1	44.6 a	23.2	28.6	46.1	17.4	25.6	37.9 ab
Barliza	19.9 b	26.8	44.3 a	22.9	28.4	46.1	17.6	25.6	37.0 a
Timfor	20.7 ab	26.7	44.2 a	23.1	28.3	46.7	17.8	26.2	36.1 a
PXTA-01	19.9 b	26.2	44.1 a	24.9	26.1	43.9	17.2	27.3	42.3 b
Climax	21.4 a	26.3	43.8 a	23.3	28.4	46.5	17.0	26.6	35.6 a
Mean	20.0	26.7	44.8	23.5	28.1	46.1	17.3	26.6	38.6
CV (%)	5	1	4	5	7	6	8	5	9
LSD (0.05)	1.5	NS	2.7	NS	NS	NS	NS	NS	5.3

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 5. Pounds of crude protein for six timothy varieties for each of three cuttings and the total for 2001 at Klamath Experiment Station, Klamath Falls, OR.

Variety	Cutting 1	Cutting 2	Cutting 3	Total
	lb /acre			
Clair	310	400	470 a	1180
PXTA-04	270	500	290 c	1050
Barliza	350	420	270 c	1040
Timfor	270	420	340 bc	1020
PXTA-01	250	290	400 ab	930
Climax	210	390	320 bc	920
Mean	270	400	350	1020
CV (%)	25	30	20	17
LSD (0.05)	NS	NS	105	NS

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 6. Yield of eight orchardgrass varieties for each of three cuttings and the total for 2001 at Klamath Experiment Station, Klamath Falls, OR.

Variety	Cutting 1	Cutting 2	Cutting 3	Total
	lb /acre			
Stampede	1160 a[1]	3170 a	3100 a	7430 a
Quantum	980 a	2580 ab	3480 a	7040 a
Latar	1260 a	2200 abc	3080 a	6540 ab
Potomac	1060 a	1890 bcd	3550 a	6500 ab
Mammoth	1040 a	1960 bcd	3070 ab	6060 abc
Hallmark	940 ab	1190 d	3030 ab	5160 bc
Baridana	510 c	1560 cd	2990 ab	5060 c
Sparta	630 bc	1860 bcd	2460 b	4950 c
Mean	950	2050	3100	6090
CV (%)	25	33	13	16
LSD (0.05)	340	980	610	1400

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 7. Yield of eight orchardgrass varieties for each of three cuttings and the total for 2001 at Intermountain Research and Extension Center, Tulelake, CA.

Variety	Cutting 1	Cutting 2	Cutting 3	Total
	lb /acre			
Stampede	2800 bc[1]	7000	5000	14800
Quantum	2600 c	8000	6800	17200
Latar	3600 ab	6800	5400	15800
Potomac	2800 bc	6800	5200	14800
Mammoth	3800 a	7200	5600	16600
Hallmark	3200 abc	7000	5400	15600
Baridana	2600 c	7400	4800	14800
Sparta	2400 c	7600	4400	14600
Mean	2960	7220	5340	15520
CV (%)	20	9	23	12
LSD (0.05)	800	NS	NS	NS

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 8. Percent heading of eight orchardgrass varieties for each of three cuttings and the average over cuttings for 2001 at Klamath Experiment Station, Klamath Falls, OR.

Variety	Cutting 1	Cutting 1 + 2 Weeks	Cutting 2	Cutting 3	Average
	%				
Stampede	25 bc[1]	45	1 bc	5	10 abc
Quantum	13 de	45	5 a	3	7 c
Potomac	18 cd	45	1 c	5	8 c
Latar	24 bc	45	1 c	2	9 bc
Mammoth	38 a	55	1 bc	1	13 a
Baridana	16 cde	55	4 ab	2	8 c
Hallmark	30 ab	50	2 bc	3	12 ab
Sparta	8 e	40	3 abc	2	3 d
Mean	21	48	2	3	9
CV (%)	30	---	86	106	27
LSD (0.05)	10	---	3	NS	3

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 9. Percent crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF) of eight orchardgrass varieties for each of three cuttings for 2001 at Klamath Experiment Station, Klamath falls, OR.

Variety	--------Cutting 1--------			--------Cutting 2--------			--------Cutting 3--------		
	CP	ADF	NDF	CP	ADF	NDF	CP	ADF	NDF
	%								
Stampede	23.0	23.6 a[1]	48.7 abc	24.9 ab	27.3	52.6	17.7	30.8 ab	51.6 ab
Quantum	20.9	26.3 c	50.6 c	24.3 abc	27.9	54.2	16.8	32.7 c	53.0 bc
Latar	22.5	23.8 ab	46.5 a	22.6 cd	28.3	52.8	17.1	30.7 ab	51.0 a
Potomac	22.8	25.8 c	48.4 abc	25.5 a	27.1	53.9	18.7	30.0 a	52.6 bc
Mammoth	23.4	25.1 abc	49.6 bc	26.5 a	25.3	52.3	17.5	32.1 bc	52.8 bc
Hallmark	21.3	25.0 abc	47.6 ab	23.1 bcd	28.7	53.8	17.6	31.7 abc	54.1 c
Baridana	22.0	25.6 bc	50.5 c	22.4 cd	28.8	53.8	18.4	30.8 ab	50.8 a
Sparta	22.5	26.1 c	50.5 c	21.3 d	29.9	55.2	18.4	30.1 a	50.3 a
Mean	22.3	25.2	49.1	23.8	27.9	53.6	17.8	31.1	52.0
CV (%)	5	5	4	6	7	3	6	4	2
LSD (0.05)	NS	1.8	2.7	2.3	NS	NS	NS	1.7	1.5

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 10. Pounds of crude protein for eight orchardgrass varieties for each of three cuttings and the total for 2001 at Klamath Experiment station, Klamath Falls, OR.

Variety	Cutting 1	Cutting 2	Cutting 3	Total
	lb /acre			
Stampede	260 ab[1]	800 a	550 ab	1610 a
Quantum	200 bc	620 ab	590 ab	1410 a
Potomac	240 ab	470 bc	670 a	1380 a
Latar	290 a	500 bc	530 b	1310 ab
Mammoth	240 ab	510 bc	550 ab	1300 ab
Baridana	110 d	350 bc	560 ab	1020 b
Hallmark	200 bc	270 c	530 ab	1010 b
Sparta	140 cd	390 bc	460 b	990 b
Mean	210	490	550	1250
CV (%)	24	38	17	19
LSD (0.05)	76	271	136	355

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Relationships Among Quality Components in Cool-season Grasses Following Varied Rates of Nitrogen Fertilizer

Donald R. Clark and Jim E. Smith[1]

Abstract

Plant constituents that influence the nutritive value of forages are all formed from carbon chains produced in photosynthesis. This study investigates the relationship of certain of these constituents in four forage grasses (orchardgrass, tall fescue, annual ryegrass, and perennial ryegrass), that received varied rates of nitrogen (N) fertilization. Forage constituents studied included nitrogenous compounds, classed as crude protein (CP), and carbohydrate-based compounds including acid detergent fiber (ADF), neutral detergent fiber (NDF), and total nonstructural carbohydrates (TNC). With quantitative N fertilizer rates, regression and correlation statistical analyses were completed on yield, concentrations of the quality constituents, N efficiencies, and protein removed in hay. Tall fescue exhibited increased yields over the first three N fertilization rates and then yield declined slightly at the highest rate. Though not observed in all cases, increasing N fertilization rates caused concentration of CP in the forages to increase and concentrations of ADF, NDF, and TNC to decrease. When correlating the constituents, CP was inversely related to the carbohydrate-based compounds. Concentrations of ADF, NDF, and TNC were positively correlated with each other. Nitrogen efficiencies were highest at the lowest N fertilization rates and declined with increasing N fertilization rates.

Introduction

Photosynthesis in forages and all other plants is the source of skeletal carbon chains that are the backbones for biochemical compounds. In cool-season forage grasses, the initial compound in this reaction is the three-carbon species, 3-phosphoglyceric acid. This basic building block compound goes through a variety of chemical conversions to form all of the biochemical species found in cool-season grass forages, including carbohydrates, lipids, or nitrogenous compounds. The nitrogenous compounds can be proteins, nucleotides, or other compounds. The formation of the various biochemical products is dictated by dynamic equilibriums that are driven by concentrations of enzymes, concentrations of substrates, and environmental conditions (Goodwin and Mercer 1972).

Carbohydrates in grasses occur in structural and nonstructural forms. Cell walls are the major structural units and are the chief source of plant fiber. Carbohydrates associated with cell walls include cellulose, the most common biochemical compound in nature, hemicellulose, and pectic compounds. Non carbohydrate materials in cell walls include organic lignins, minerals, and silicates (Buxton and Mertens 1995). Cellulose is indigestible in simple-

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stomached animals but can be broken down in ruminant animals by bacterial enzymes. Hemicellulose is moderately digestible while pectic compounds are almost totally digestible. Livestock can use minerals found in cell walls but no class of livestock can digest lignin or silicates (Paterson et al. 1994).

There are two main analytical methods used to determine the fiber content of forages. The first of these uses a neutral detergent solution to extract pectic compounds and cell contents. The remaining material left after this extraction is known as NDF and is comprised mainly of cellulose, hemicellulose, lignin, minerals, and silica. This particular fiber has been used as an indicator for the amount of feed that livestock can intake.

The other common forage analysis uses acidic detergent solution to extract non fiber components. The remaining fiber is known as ADF. The main difference between the two fibers is that NDF includes hemicellulose. ADF is used as an index for forage digestibility.

Non structural carbohydrates consist of simple and complex sugars that are totally digestible. These carbohydrates supply energy for plant metabolism. The complex forms of these sugars, fructosans for cool-season grasses and starches for warm-season grasses, provide energy for plants during dormant periods or for regrowth needs after grazing or hay harvests. The total of these simple and complex sugars is classified as TNC (Goodwin and Mercer 1972).

Most nitrogen in forages is found in organic compounds containing amino groups. These include amino acids, the building blocks of peptides and proteins, and nucleotides, compounds that store and allow genetic information to be expressed. These two nitrogenous classes of compounds make up most of the CP of forages. Concentrations of CP in forages vary with species and maturity of the forages (Goodwin and Mercer 1972).

With the addition of any agronomic input, questions arise as to the efficiency that a crop will exhibit in using that input. Excessive N use leads to two major concerns. The first is the movement of nitrate to ground or surface water. Nitrate is very soluble and is transported with water that leaves the treated site (Follett and Wilkinson 1995).

The second concern is the accumulation of forage nitrate that can be toxic to livestock. Uptake of N in excess of amounts synthesized into nitrogenous organic compounds results in nitrate accumulation. This accumulation can be amplified under conditions of environmental stress that retards conversion of inorganic N to organic N. These stresses include cold, hot, or dry conditions that limit plant metabolism. Concentrations of nitrate in forages under 0.5 percent is considered safe. Concentrations from 0.5 to 2.0 percent can be toxic and it is recommended that forages containing this level should not be used as the only source of feed. Forages with concentrations of nitrates above 2.0 percent should not be fed to livestock (Follett and Wilkinson 1995).

Forage growth is highly correlated with the availability of nitrogen. A trial was established to increase the understanding of the relationships among nitrogen fertilization and forage growth and plant constituents. This trial involved four cool-season grass forages that received varied rates of nitrogen fertilizer. It is hoped that producers can use relationships between CP, ADF, NDF, TNC, and forage persistence to make management decisions.

Procedures

A late-summer seeded trial was established on a field with Poe fine sandy loam soil that had grown oats for hay earlier in the season. This field was ripped to 12- to 18-in depth in July, followed by moldboard plowing, disking, and harrowing. A Brillion packer was pulled behind the harrow on the last pass to form a smooth, firm seedbed. Prior to seeding, plots received broadcast fertilizer treatments of 50 lb N, 62.5 lb P_2O_5, and 41 lb S/acre (16-20-0-13 at 310 lb/acre).

The trial was established on August 17, 2000 in a four by four randomized block factorial design with four replications. Tested forages were Potomac orchardgrass, Fawn tall fescue, Hercules annual ryegrass, and Baristra perennial ryegrass. The grasses were seeded at 0.25- to 0.5-in depth using a Kincaid (Kincaid Equipment Manufacturing) experimental plot planter with 6-in drill spacings. A seeding rate of 20 lb/acre was used for each grass. Plots were 4.5 ft wide and 20 ft long.

Nitrogen fertilizer treatment applications were applied early in the 2001 growing season and immediately following the first two harvests. The fertilizer treatments were 25, 50, 100, or 200 lb N/acre using URAN (32 percent N) solution for each application. Including the preplant N applications, total N rates of 125, 200, 350, and 650 lb N/acre were applied.

Prior to each of three harvests completed in the 2001 growing season, 5.5-ft strips were cut between the plots to prevent sample mixing. Harvests were made with a Carter (Carter Manufacturing Co., Inc.) self-propelled flail harvester with a 3-ft-wide header on May 30, July 5, and September 7. Random samples of about 1 lb from each plot were oven dried to determine dry matter yield. Dried samples were ground to pass a 2-mm sieve in a Wiley Mill (Arthur H. Thomas Co.) and then to pass a 1-mm sieve in a Udy Mill (UDY Corporation). These ground samples were then analyzed in a near infrared spectrophotometer (NIRS, NIRSystems) to determine CP, ADF, and NDF. Analyses of TNC were completed on the samples following an acid extraction using an anthrone solution as the indicator.

Data analyses were completed using SAS software. With the quantitative fertilizer treatments, standard ANOVA and means separation procedures were not applicable for this trial. Using orthogonal polynomials, it is valid to consider regression equations up to the cubic level with the four fertilizer rates. Regression analysis relates causative independent variables and resulting dependent variables. In this trial, these regressions compared the affect of the varying N fertilization rates on yields and concentrations of quality constituents. Linear correlations were also determined between plant constituents to define relationships. Correlation analysis compares dependent factors but does not attempt to establish cause and effect relationships.

Results and Discussion

Irrigation water from the Klamath Irrigation District was available from July 25 until August 23. Additional irrigation from a sump that collects water from tile drains was applied prior

Nitrogen Use Efficiencies

Nitrogen efficiencies were calculated by dividing N removed by N input. Input N included residual N assumed to equal 110 lb N/acre, fertilizer N applied preplant, early season, and after the first two cuttings. N removed was calculated as yield multiplied by CP to obtain harvested CP. This value was then converted to N removed by dividing by 0.16. The assumed residual N was the largest difference in N input and N removed for all of the plots.

Regression analyses were completed on N input compared with N efficiencies and CP removed in hay. These regressions did not indicate significance for any species or cutting. However, trends appeared evident and are included in Figure 10. For orchardgrass and tall fescue, the lowest two fertilizer rates produced similar N efficiencies; the efficiencies dropped off at the higher two rates. For both of the ryegrass species efficiencies were maximized at the lower N fertilizer rates and steadily declined with increasing fertilizer rates. Low N fertilizer rate efficiencies were 78, 79, 74, and 71 percent for orchardgrass, tall fescue, annual ryegrass, and perennial ryegrass, respectively. These efficiencies declined at the higher N rates to 39, 49, 42, and 27 percent, respectively.

Removal of protein in orchardgrass was lowest at the low N rates, increased for the next two rates, but then slightly declined at the highest N fertilizer rate. Annual ryegrass protein varied only slightly over the N fertilizer rates, while protein removal for tall fescue and perennial ryegrass tended to increase throughout the range of increasing N fertilizer rates.

Summary

While the results obtained in the first year of this study are preliminary and were influenced by limited irrigation, general observations are of interest for local forage producers. Forage yields were highest for tall fescue followed by perennial ryegrass, orchardgrass, and annual ryegrass. Yield response to N fertilizer rate declined in that order among species. Increasing N fertilizer rates generally resulted in higher crude protein content but lower ADF, NDF, and TNC.

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Paterson, J.A., R.L. Belyea, J.P. Bowman, M.S. Kerley, and J.E. Williams. 1994. The impact of forage quality and supplementation regimen on ruminant animal intake and performance. Pages 59-114 *In* G.C. Fahey (ed.), Forage Quality, Evaluation, and Utilization. American Society of Agronomy, Madison, WI.

Table 1. Yield of four grass species at four N fertilizer rates for each of three cuttings and the total for 2001 at Klamath Falls, OR.[1]

Species (Variety)	N Rate	Cutting 1	Cutting 2	Cutting 3	Total
		lb/acre			
Orchardgrass (Potomac)	25	1900	1680	3040	6620
	50	2220	2720	3190	8140
	100	1890	1730	3770	7390
	200	2700	2340	3220	8260
Tall fescue (Fawn)	25	2080	1130	3200	6410
	50	2910	1620	4240	8770
	100	3430	2360	4920	10710
	200	3710	2620	5010	11330
Annual ryegrass (Hercules)	25	3060	1380	1930	6370
	50	3470	1340	2210	7020
	100	4190	1050	1600	6840
	200	4390	1000	1630	7020
Perennial ryegrass (Baristra)	25	3290	790	2310	6380
	50	3710	1140	2570	7410
	100	4640	1130	3610	9370
	200	4590	1270	3800	9670

[1]Due to the quantitative treatments, standard ANOVA and mean separation statistical methods are not applicable.

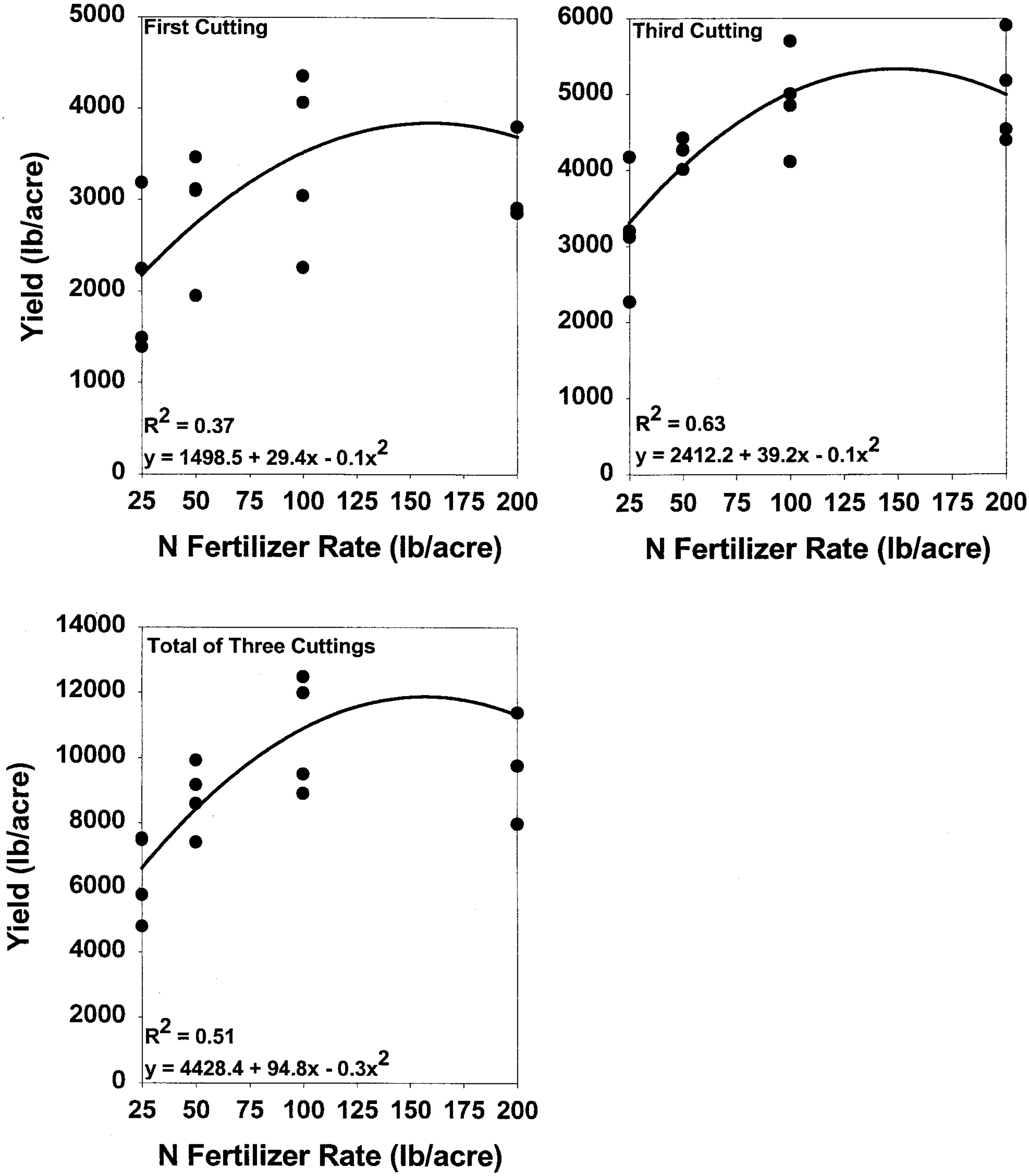

Figure 1. Effects on yield of Fawn tall fescue with increasing N fertilizer rates, Klamath Falls, OR, 2001.

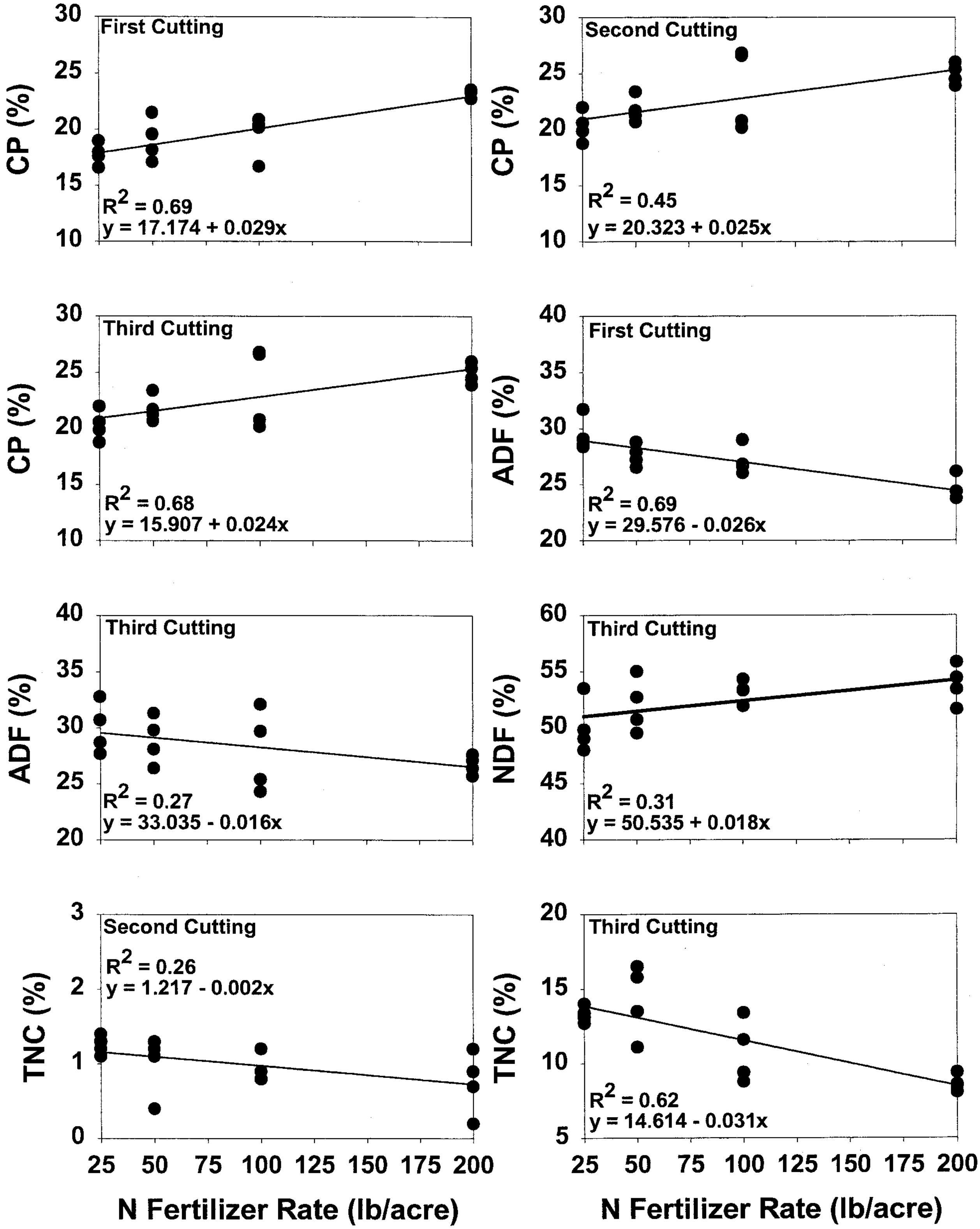

Figure 2. Effects on forage quality of Potomac orchardgrass with increasing N fertilizer rates, Klamath Falls, OR, 2001.

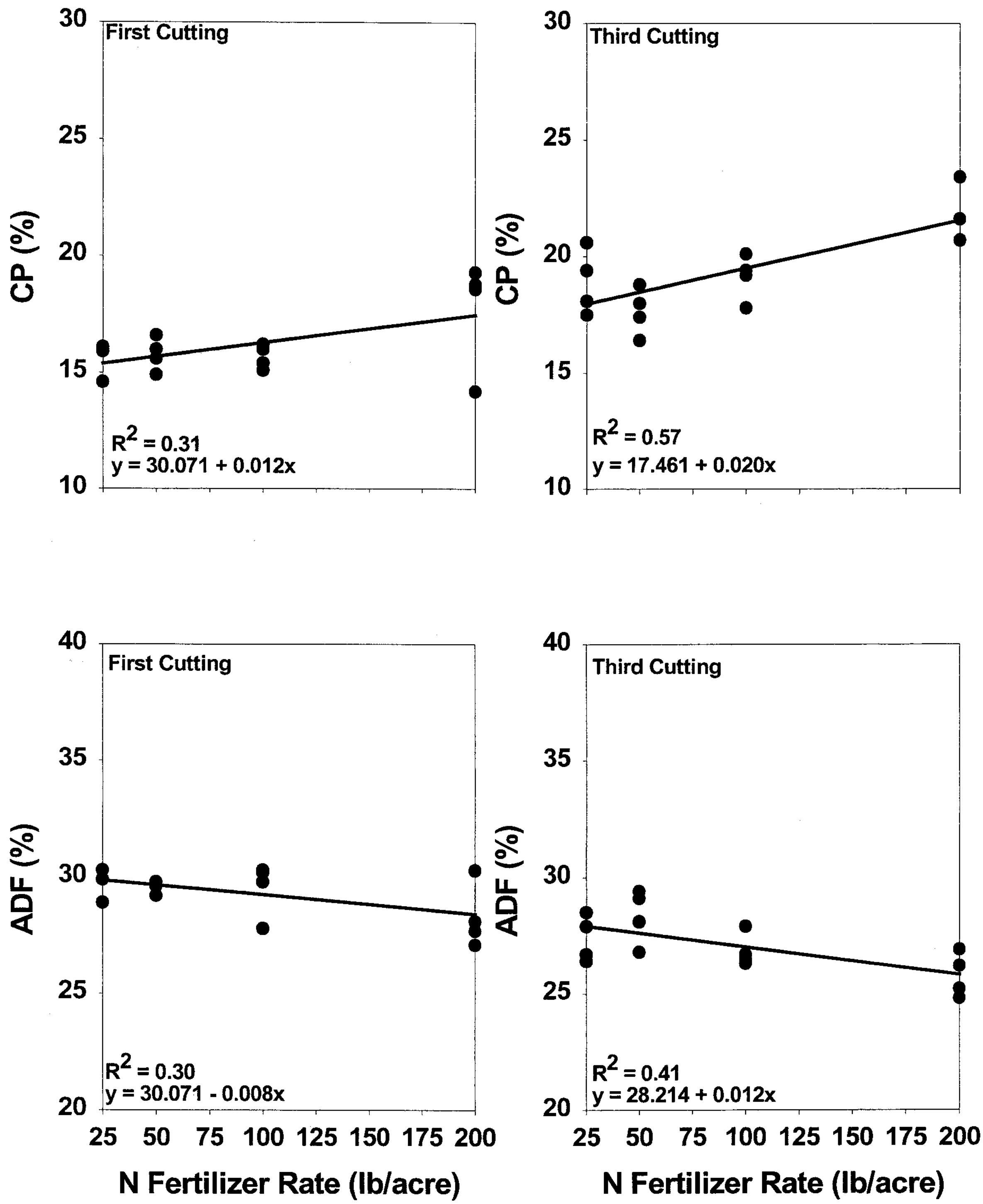

Figure 3. Effects on forage quality of Fawn tall fescue with increasing N fertilizer rates, Klamath Falls, OR, 2001.

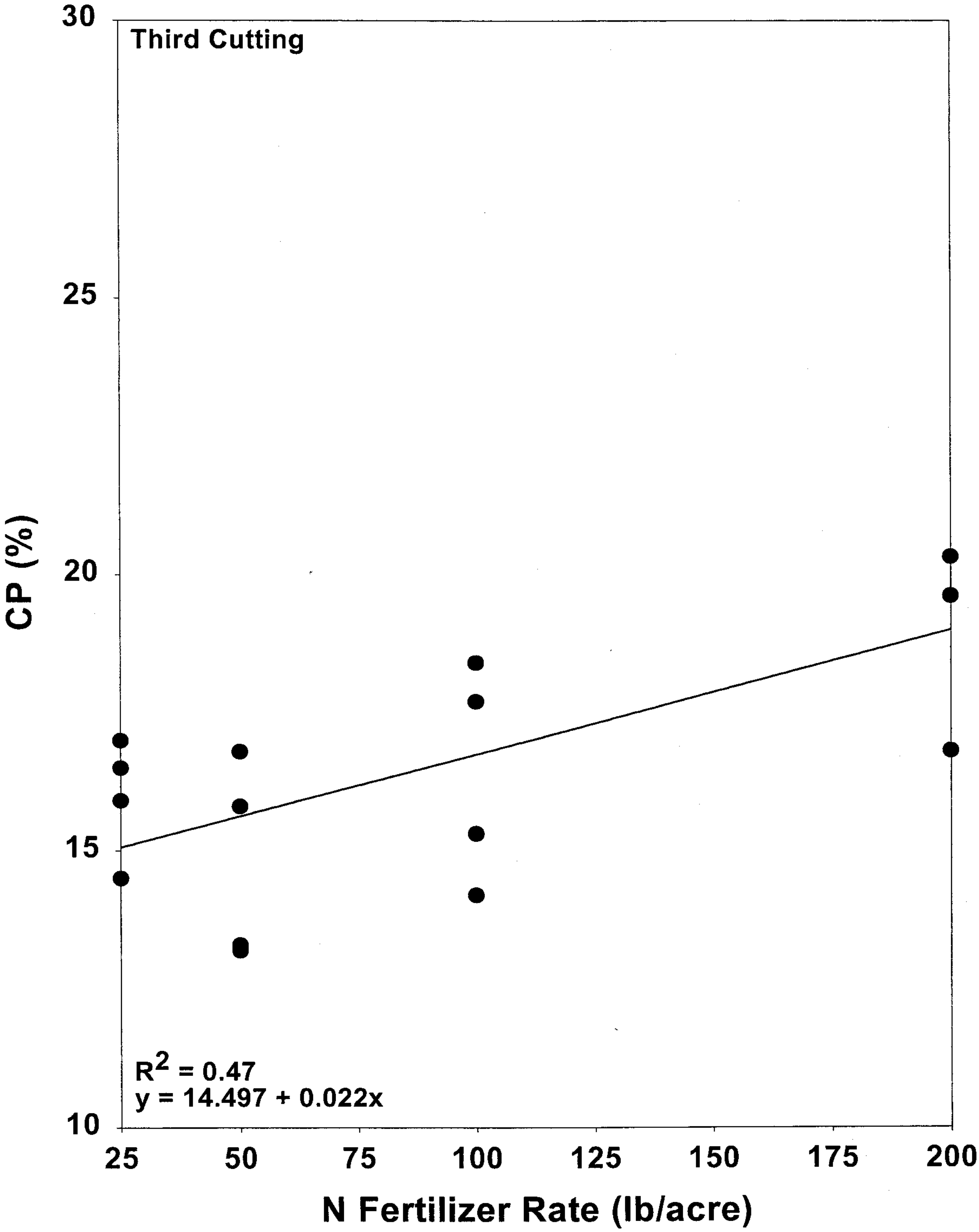

Figure 4. Effects on forage quality of Hercules annual ryegrass with increasing N fertilizer rates, Klamath Falls, OR, 2001.

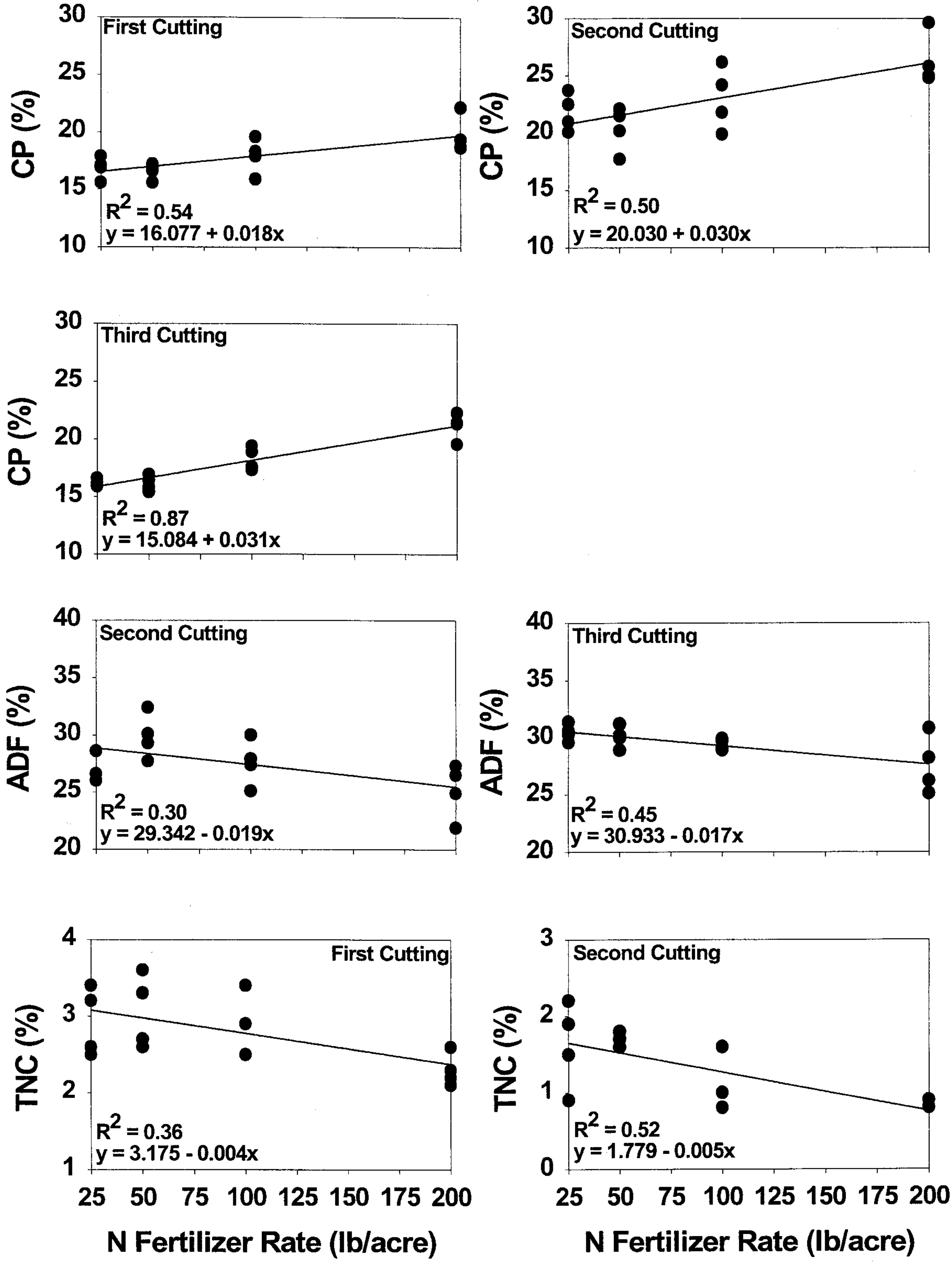

Figure 5. Effects on forage quality of Baristra perennial ryegrass with increasing N fertilizer rates, Klamath Falls, OR, 2001.

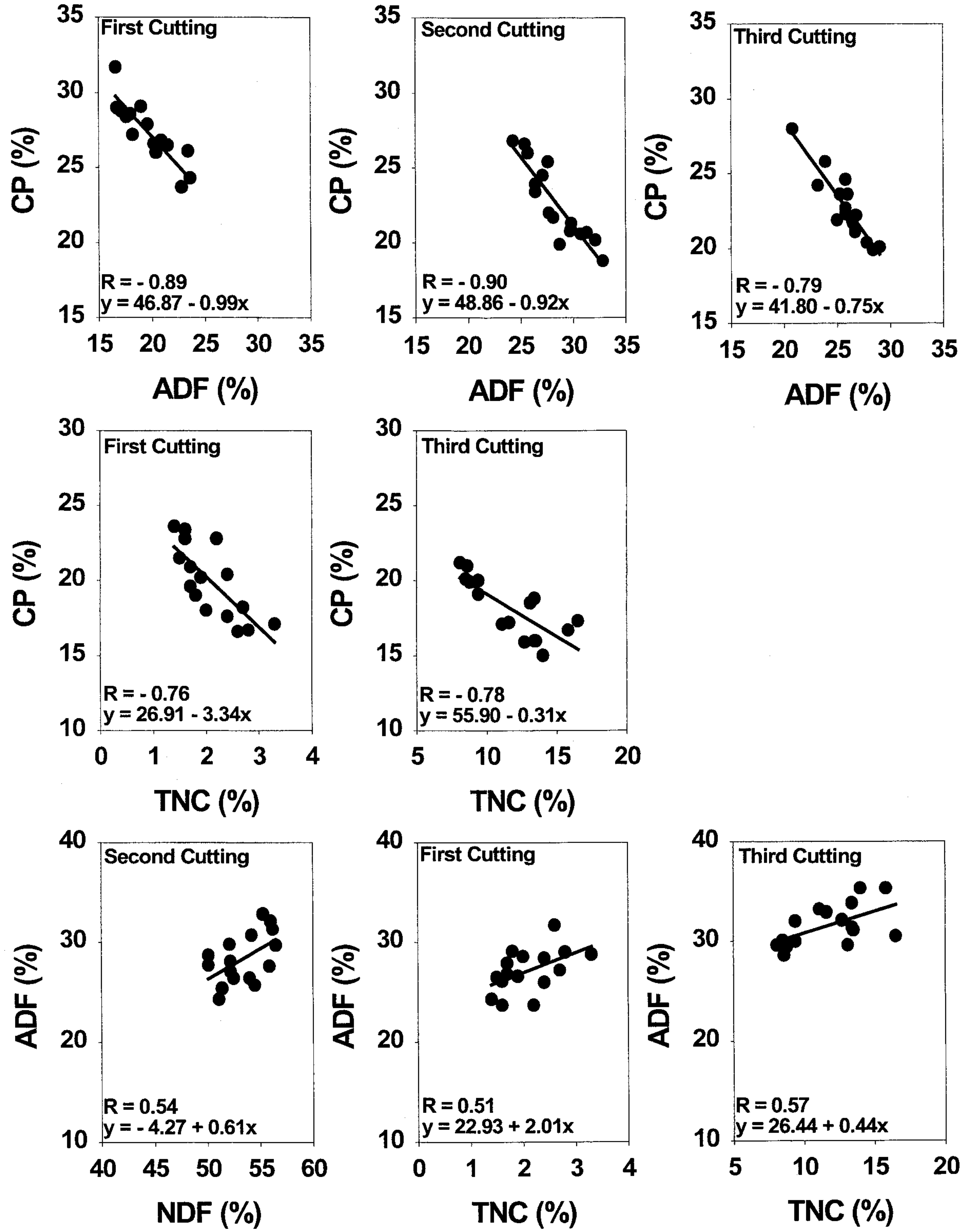

Figure 6. Correlations of forage quality constituents in Potomac orchardgrass, Klamath Falls, OR, 2001.

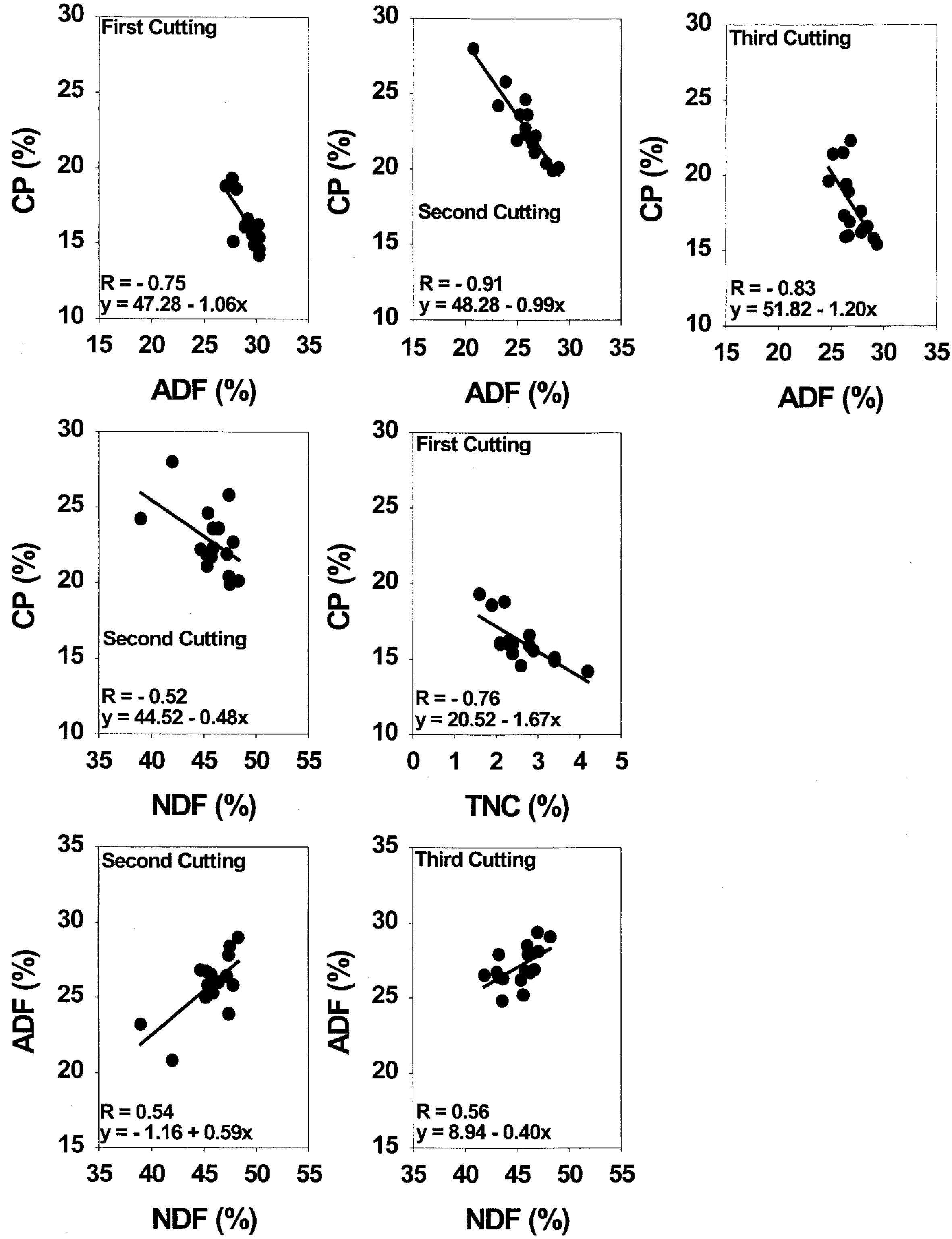

Figure 7. Correlations of forage quality constituents in Fawn tall fescue, Klamath Falls, OR, 2001.

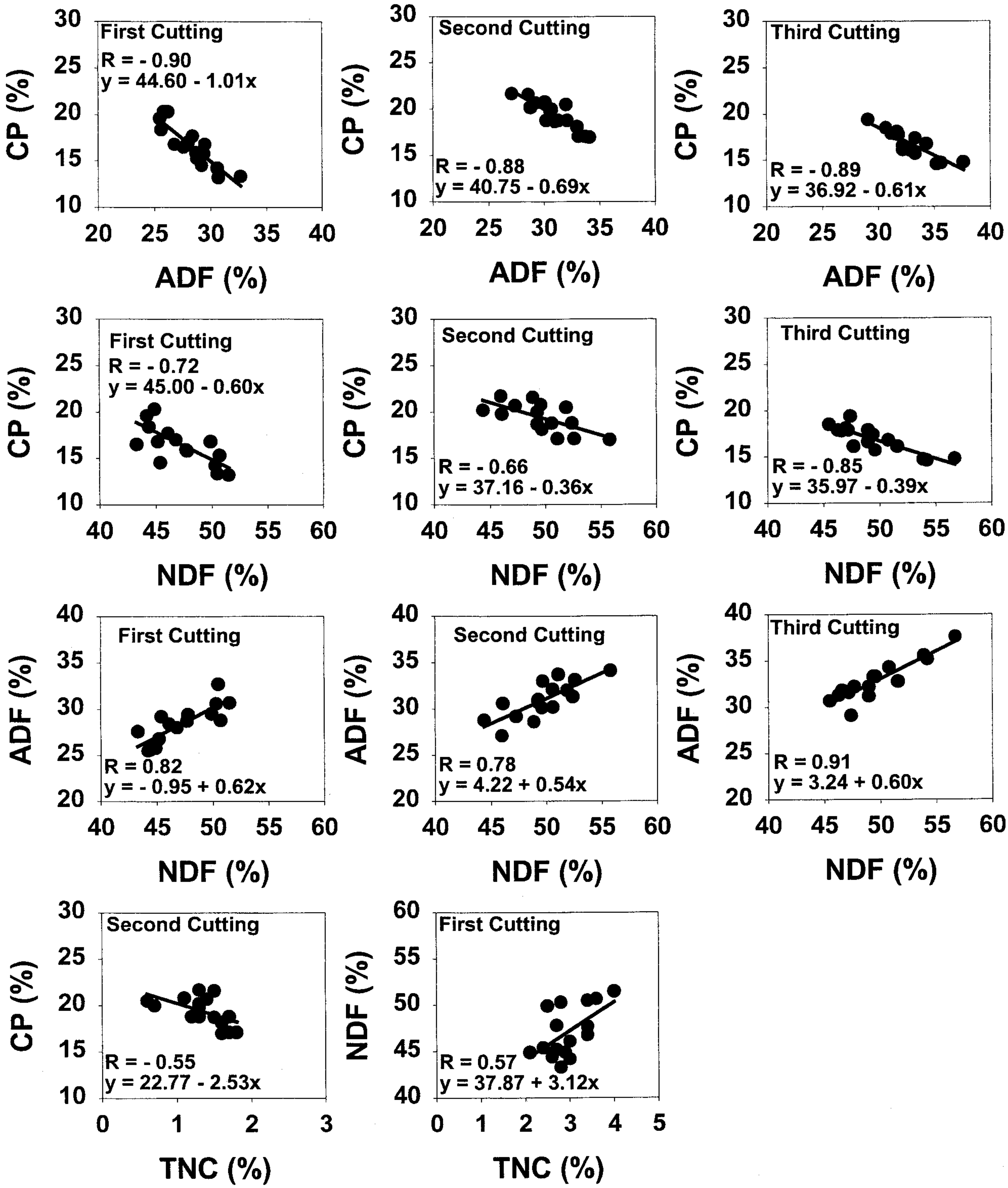

Figure 8. Correlations of forage quality constituents in Hercules annual ryegrass, Klamath Falls, OR, 2001.

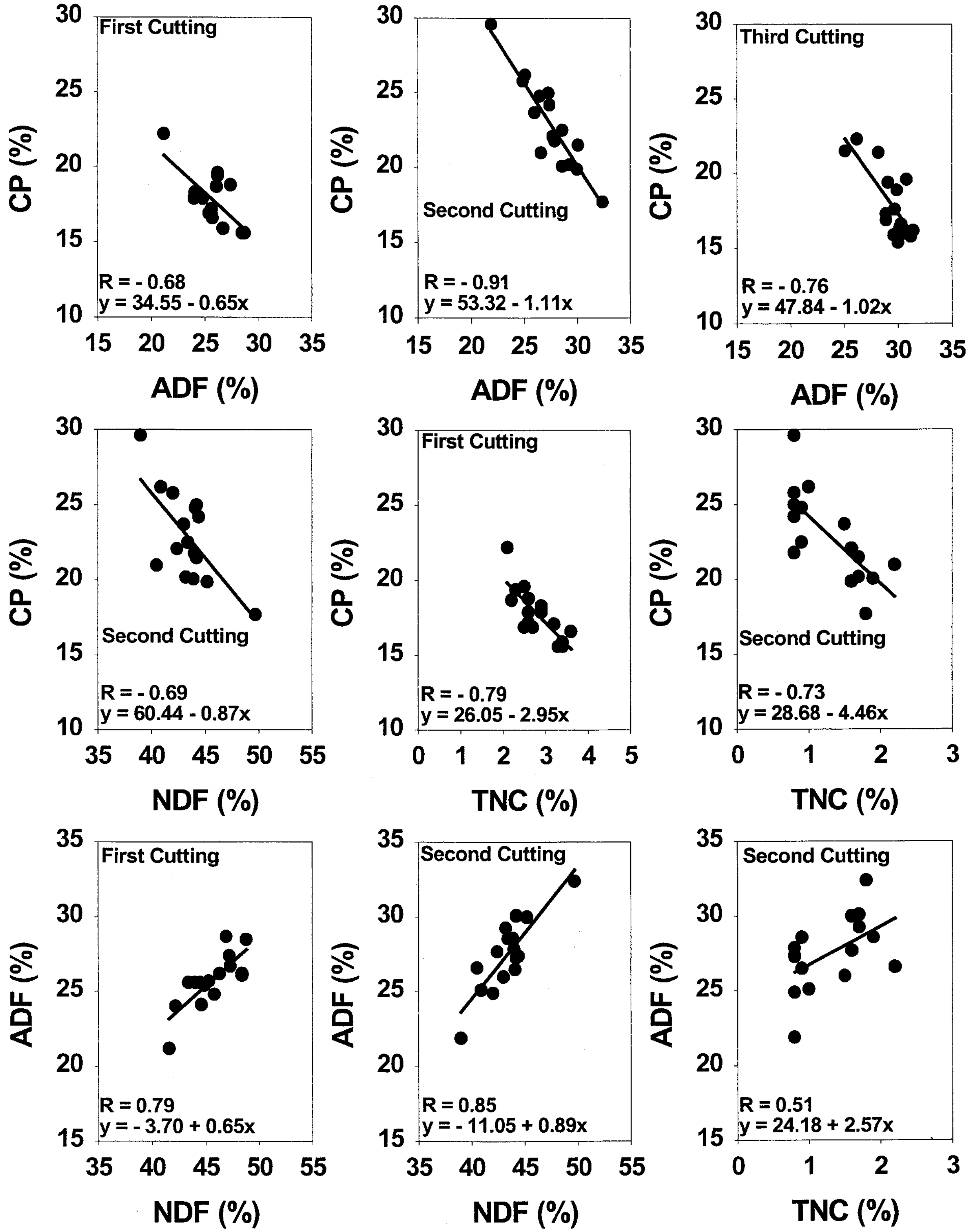

Figure 9. Correlations of forage quality constituents in Baristra perennial ryegrass, Klamath Falls, OR, 2001.

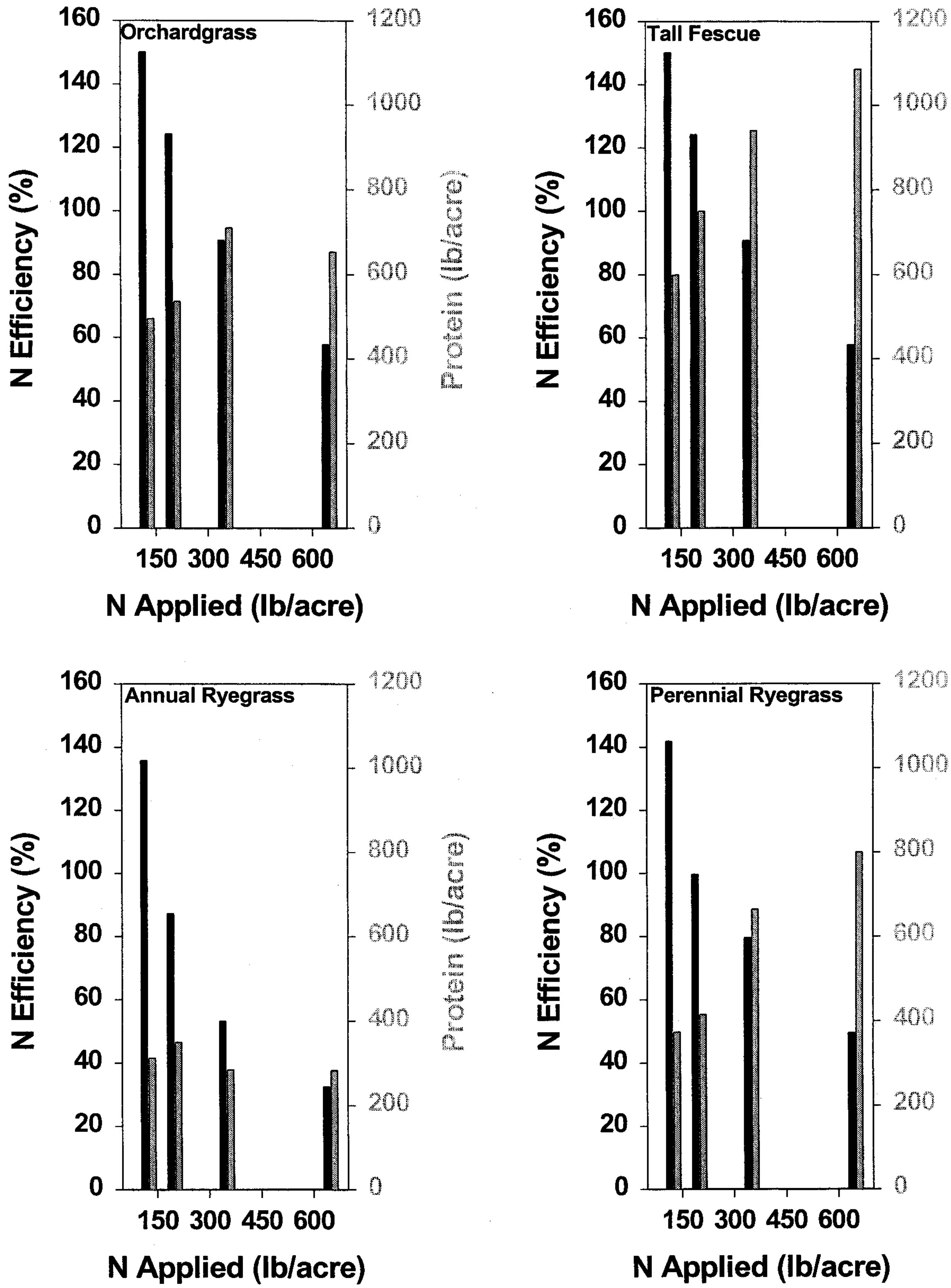

Figure 10. N efficiency and protein removed with three cuttings over varying N fertilizer rates for four forage species, Klamath Falls, OR, 2001.

Timothy Establishment Trials

Donald R. Clark and Jim E. Smith[1]

Abstract

Trials were initiated in late summer of 2000 to determine optimum seeding rates and methods for establishment of timothy hay. During the 2001 growing season, three cuttings were completed on these trials. Data from these cuttings indicated that seeding timothy in drill rows produced higher yields than broadcast seeding with various packing methods. Seeding rate response was found to vary depending on variety. Timfor yields declined with increasing seeding rates from 4 to 10 lb/acre. On the other hand, yield of Clair tended to increase from the 4-lb/acre rate up to about 8 lb/acre and then declined up to 10 lb/acre. With any perennial forage crop, establishment recommendations require results over time to insure crop performance over the varying climatic conditions encountered by producers. This report provides information for only one atypical year. The data will be combined with findings from future years to provide more definitive recommendations.

Introduction

Timothy is a shallow-rooted bunch grass adapted to moist, cool conditions. The shallow rooting system limits its adaptability on droughty soils. High temperatures and saline or alkaline soils also can limit production. Timothy stores energy reserves for regrowth and tillering in its haplocorm or corm, an enlarged bulbous stem structure at the stem base. This energy storage strategy results in timothy being better suited to hay production than as a pasture species.

Timothy commands a higher price than other grass species. Demand for this hay in the horse industry and for export to Pacific Rim countries has driven prices up to and over $150/ton. The highest prices are paid for timothy hay with long seed heads. Other than for weather damaged hay, the major factor causing price discounts is the presence of "red leaf", a condition where lower leaves desiccate before harvest. The condition has been related to overcrowded stand, nitrogen management, and insect damage.

Timothy's small seed size increases establishment difficulties. With a small seed, excessive planting depth results in the energy stored in the seed being inadequate for emergence. Thus it is necessary to plant timothy shallow, less than 0.5 in. However, maintaining adequate moisture with shallow seeding depths can be a challenge. A fine seedbed will allow good seed/soil contact that will optimize moisture retention and seed emergence.

Many questions face producers in growing timothy in the Klamath Basin. These include proper seeding rates to maximize yield and forage quality, including the minimization of red leaf. Is it better to broadcast seed or use drill rows and, if in drill rows, what is the optimum spacing for drill rows? To investigate these questions, two trials were established at the Klamath Experiment Station (KES) in the late summer of 2000. This report provides

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findings from the first year of these trials.

Procedures

Two late-summer seeded timothy trials were established on a field with Poe fine sandy loam soil that had grown oats for hay earlier in the season. This field was ripped to 12- to 18-in depth in July, followed by mold-board plowing, disking, and harrowing. A Brillion packer was pulled behind the harrow on the last pass to form a smooth, firm seedbed. Prior to seeding, plots received broadcast fertilizer treatments of 50 lb N, 62.5 lb P_2O_5, and 41 lb S/acre (16-20-0-13 at 310 lb/acre). Nitrogen (N) fertilizer applications were also applied at 50 lb N/acre using URAN (32 percent N) solution early in the 2001 growing season and immediately following the first two harvests. Plots were 4.5 ft wide and 20 ft long. One trial evaluated a single timothy variety at two seeding rates with five different seeding practices. The other trial consisted of three timothy varieties planted at four different seeding rates. Both trials were seeded on August 17, 2000.

The seeding method trial was established in a five by two split plot design with four replications. Seeding method was the main plot and seeding rate the sub plots. Climax timothy was planted in one of five methods in randomized strips eight plots long. The methods evaluated included broadcast or drilled seedings. Broadcast seedings were followed by a Brillion packer, a solid metal packer, or raking to simulate a spring tooth harrow. Drilled plots were 6- or 12-in row spacings. Seeding rates of 6 and 8 lb/acre were randomly seeded within main plots. For drilled strips, seed was planted at 0.25- to 0.5-in depth using a Kincaid (Kincaid Equipment Manufacturing) experimental plot planter. The seeder has 6-in drill spacings. For 12-in drill spacings, every other drop tube was blocked off. With fewer rows being planted at the 12-in spacing, double seed rates were planted into each row. A 0.75-in-wide press wheel compacted the soil just behind the seeding operation. For broadcast plantings, drop tubes were secured 12 in above the opening discs and allowed to free flow across the 6-in spacings.

A three by four randomized block factorial design with four replications was used for the timothy seeding rate trial. Timothy varieties Climax, Clair, or Timfor, were seeded at 0.25- to 0.5-in depth using a Kincaid experimental plot planter with 6-in drill spacings. Seeding rates of 4, 6, 8, and 10 lb/acre were used.

Prior to each of three harvests completed in the 2001 growing-season, 5.5-ft strips were cut between plots to prevent sample mixing. Harvests were performed with a Carter (Carter Manufacturing Co., Inc.) self-propelled flail harvester with a 3-ft-wide header on May 30, July 5, and September 7. Random samples of about 1 lb from each plot were oven dried to determine dry matter yield. Dried samples were ground to pass a 2-mm sieve in a Wiley Mill (Arthur H. Thomas Co.) and a 1-mm sieve in a Udy Mill (UDY Corporation). Ground samples were analyzed in a near infrared spectrophotometer (NIRS, NIRSystems) to determine forage quality as measured by crude protein (CP), acid detergent fiber (ADF), and neutral detergent fiber (NDF).

Results and Discussion

Irrigation water from the Klamath Irrigation District was available from July 25 until 23 August. Additional irrigation from a sump that collects water from tile drains was applied prior to and after the surface irrigation water. The AgriMet station located at KES recorded total precipitation of 2.1 in from April 1 through the third cutting. Total irrigation applied was about 18.5 in. These two inputs totaled 20.6 in compared with the calculated evapotranspiration (ET) for cool-season grasses of 31.8 in. Thus about 65 percent of calculated ET was supplied during the trials in 2001. For the first cutting, 1.6 in of rain and 3.6 in of irrigation provided about 60 percent of the ET for cool season grasses. For the second cutting, 0.4 in of rain and 3.2 in of irrigation supplied about 25 percent of calculated ET. For the third cutting, 0.1 in of rain and 11.8 in of irrigation represented about 120 percent of calculated ET for this period.

With any perennial forage crop, establishment recommendations require results over time to ensure crop performance over the varying climatic conditions encountered by producers. This report provides information for only 1 year, a year with atypical irrigation management. These data will be compiled with data in future years to comprise more complete recommendations.

Seeding Methods

No differences were observed between 6- and 8-lb/acre seeding rates of Climax timothy. Also there was no significant interaction between seeding rate and seeding method. Therefore, yield data presented in Table 1 are averages across seeding rates for each of the seeding methods. These results indicate that drilled seedings yielded more than any of the broadcast treatments. Within drilled methods, there was a trend for higher yields with the 12-in spacing. A slight trend for the solid packed broadcast method to yield more than the other two methods, which did not pack the soil as uniformly, was also noted.

Seeding Rates and Varieties

Interactions between seeding rate and varieties were noted for the yield in the second cutting and total yield, but not in first and third cuttings. Table 2 presents yield data averaged across seeding rates for first and third cuttings with no interaction between variety and seeding rate. These data indicate that Clair was the highest yielding variety. Though not different in yield for the first cutting, Timfor yielded more than Climax in the third cutting.

Analyses of yields over all varieties and seeding rates failed to detect significant differences. Thus individual varieties were analyzed separately for response to seeding rates. Since the seeding rates were quantitative treatments, regression analyses considering linear, quadratic, and cubic regression equations were appropriate. Figure 1 contains the best-fit significant regression curves for yield response to seeding rate. For the second cutting of Timfor, a negative correlation was observed between seeding rate and yield. The 4-lb/acre seeding rate produced the highest yield followed by 6-, 8-, and 10-lb/acre rates. This was different from the response for Clair in the second cutting. A cubic regression equation produced the best-fit curve for Clair. This curve followed the general trend where yield was less for the 4- and 6-lb/acre seeding rates, maximized at about 8.5-lb/acre and then declined at the 10-lb/acre seeding rate.

Table 1. Average of Climax timothy yield across 6- and 8-lb/acre seeding rates for each of three cuttings and the total for 2001 at Klamath Falls, OR.

Establishment method	Cutting 1	Cutting 2	Cutting 3	Total
	----------lb/acre----------			
12 inch drilled	1830 a[1]	850 a	2120 a	4800 a
6 inch drilled	1590 a	640 ab	1930 ab	4160 ab
Broadcast, solid packed	1050 b	430 b	1660 abc	3140 bc
Broadcast, raked	810 b	460 b	1100 c	2360 c
Broadcast, Brillion packed	710 b	270 b	1200 c	2180 c
CV (%)	27	52	32	23
LSD (0.05)	450	380	700	1070

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

Table 2. Average yields for three timothy varieties across 4-, 6-, 8-, and 10-lb/acre seeding rates for the first and third cuttings for 2001 at Klamath Falls, OR.

Variety	Cutting 1	Cutting 3
	----------lb/acre----------	
Clair	2820 a[1]	2720 a
Timfor	1230 b	2140 b
Climax	1200 b	1780 c
CV (%)	29	17
LSD (0.05)	360	280

[1]Values within columns followed by the same letter are not significantly different (p = 0.05).

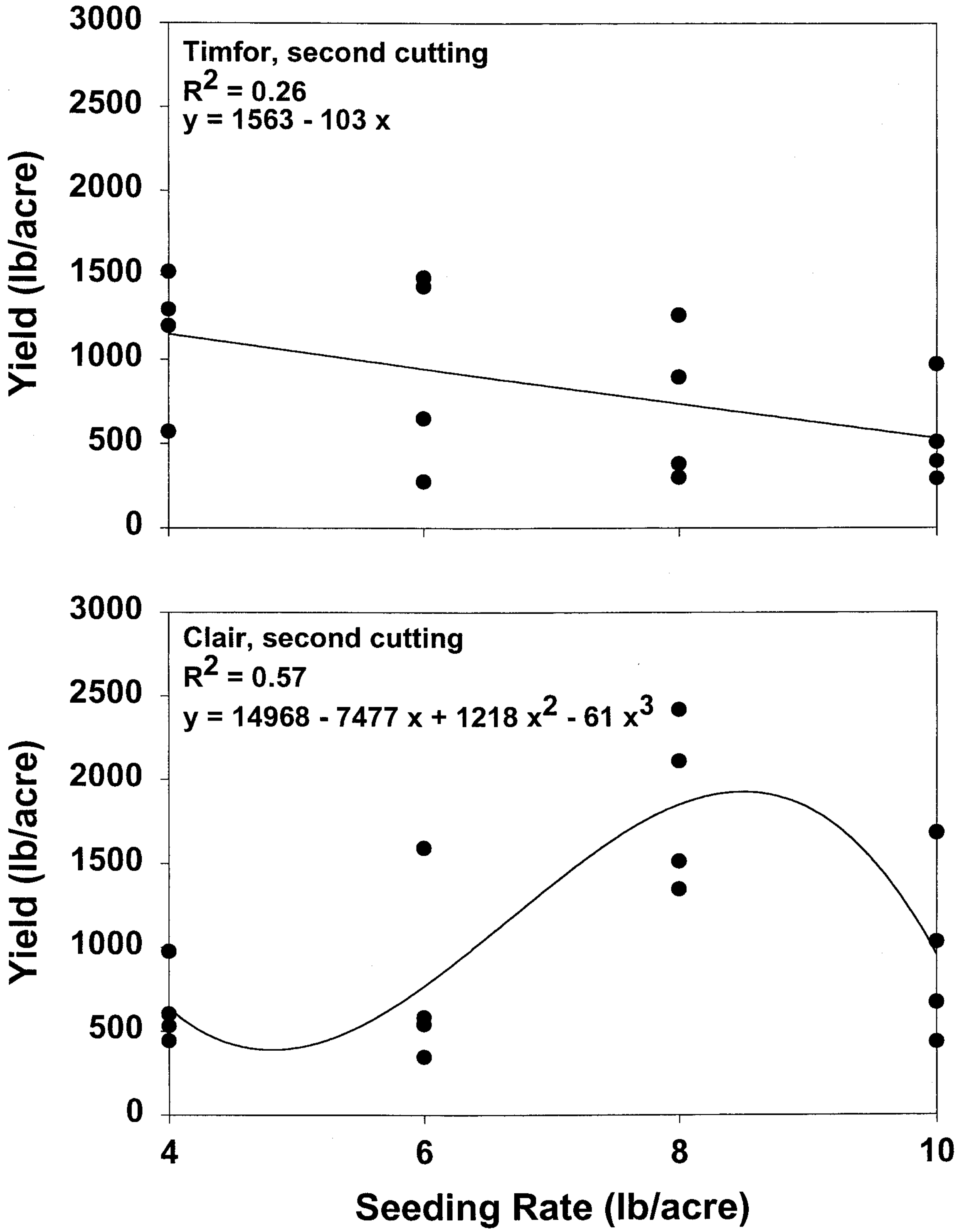

Figure 1. Significant regressions between seeding rate and yield of timothy, Klamath Falls, OR, 2001