HortScience 38(6):1117–1121. 2003.

'Umatilla Russet' and 'Russet Legend' Potato Yield and Quality Response to Irrigation

C.C. Shock[1], E.B.G. Feibert[2], and L.D. Saunders[3]
Malheur Experiment Station, Oregon State Univesity, 595 Onion Avenue, Ontario, OR 97914

S.R. James[4]

Central Oregon Agricultural Research Center, Madras, OR 97741

Additional index words. *Solanum tuberosum*, soil water potential, evapotranspiration, 'Russet Burbank', 'Shepody', 'Frontier Russet', 'Ranger Russet'

Abstract. **'Umatilla Russet' and 'Russet Legend', two newly released potato (*Solanum tuberosum* L.) cultivars were compared with four established cultivars ('Russet Burbank', 'Shepody', 'Frontier Russet', and 'Ranger Russet'). Potatoes were grown under four, season-long, sprinkler irrigation treatments in three successive years (1992–94) on silt loam soil in eastern Oregon. At each irrigation, the full irrigation treatment received up to the accumulated evapotranspiration (ET_c) since the last irrigation. Three deficit irrigation treatments had progressively less water. The new cultivars 'Umatilla Russet' and 'Russet Legend' performed as well as or better than the other cultivars in the full irrigation treatment, with 'Umatilla Russet' showing a higher yield potential at the higher water application rates than 'Russet Legend'. All cultivars produced more U.S. No. 1 tubers than 'Russet Burbank', except in 1993, an unusually cool and wet year. 'Russet Legend' was the only cultivar showing a tolerance to deficit irrigation. In two out of the three years, 'Russet Legend' was as productive of U.S. No. 1 yield over most of the range of applied water as 'Shepody', 'Frontier Russet', and 'Ranger Russet' were at the higher end of the applied water range. Chemical names used: 0,0-diethyl *S*-[(ethylthio) methyl] phosphorodithioate (phorate); *N*-(1-ethylpropyl)-3,4-dimethyl-2,6-dinitrobenzenamine (pendimethalin); and 2-chloro-*N*-(2-ethyl-6-methylphenyl)-*N*-(2-methoxy-1methyl-ethyl) acetamide (metolachlor).**

The release of new cultivars and their adoption by growers and processors makes it desirable to determine cultivar tolerance to deficit irrigation. 'Umatilla Russet' and 'Russet Legend' have recently been released by the Agricultural Experiment Stations of Oregon, Idaho, and Washington and the U.S. Dept. of Agriculture in 1998 (Mosley et al., 2000a, b). Potato cultivars can differ in their tolerance to water stress (Jefferies and MacKerron, 1993a, 1993b; Lynch and Tai, 1989; Lynch et al., 1995; Martin and Miller, 1983; Miller and Martin, 1987a, b; Shock et al., 1993). Western U.S. agriculture is under increased pressure to reduce irrigation water use and to reduce groundwater pollution (Schaible et al., 1995). Deficit irrigation, which can be defined as the deliberate under irrigation of a crop, is a strategy that could optimize crop production under scarce or costly irrigation water situations. However, deficit irrigation of potato could be difficult to manage without loss of profitability. Potato is sensitive to water stress and reductions in tuber yield and quality can result from even brief periods of water stress (Eldredge et al., 1992, 1996; Lynch et al., 1995; Shock et al., 1992, 1993; Wright and Stark, 1990).

By carefully reducing the irrigation rate for the full season, water stress levels that result in losses in potato yield and quality could be avoided. Irrigation management using sprinkler irrigation with scheduling by soil water potential could provide the level of precision necessary to successfully deficit irrigate potato.

The objective of this research was to compare two new cultivars, 'Umatilla Russet' and 'Russet Legend', with four commercial processing cultivars to determine the tuber yield and quality response to deficit irrigation. The commercial cultivars tested were 'Russet Burbank', 'Shepody', 'Frontier Russet', and 'Ranger Russet'.

Materials and Methods

The trials were conducted in three successive years on an Owyhee silt loam (coarse-silty, mixed, mesic, Xerollic Camborthids) at the Oregon State Univ. Malheur Experiment Station, in Ontario, Oregon. Potatoes followed alfalfa in 1992, and spring wheat in 1993 and 1994. Fields were bedded into 0.9 m wide hills in the fall of each year. In late April tuber seed pieces (60g) were planted at 0.23 m spacing. Residual soil nitrate-N plus ammonium-N in the upper 0.3 m in late March was 62 $kg \cdot ha^{-1}$, 45 $kg \cdot ha^{-1}$, and 30 $kg \cdot ha^{-1}$ in 1992, 1993, and 1994, respectively. Nitrogen fertilizer was applied uniformly to all plots at 22 $kg \cdot ha^{-1}$, 174 $kg \cdot ha^{-1}$, and 134 $kg \cdot ha^{-1}$ in 1992, 1993, and 1994, respectively. Because of adequate residual soil N following alfalfa in 1992, the N fertilizer was applied as a single post-emergence application. In 1993 and 1994, the N fertilizer was applied as a combination of pre-emergence and post-emergence applications. Pre-emergence applications were made within one week after planting by banding urea in both sides of the potato hill at the same level as the seed piece and offset 0.23 m to the side. N fertilizer for post-emergence applications was applied to the plots as broadcast urea immediately before an irrigation or as urea-ammonium nitrate solution injected through the sprinkler system.

In the experimental design, the four irrigation treatments were the main plots, replicated five times, and cultivars were split-plots within the main plots. Irrigation treatments were arranged in randomized complete blocks and consisted of an adequately irrigated check and three deficit irrigation treatments (Table 1). At each irrigation, the check treatment had

Table 1. Actual water applied plus precipitation and average soil water potential at two depths in response to four irrigation treatments. Crop evapotranspiration, ET_c, was estimated to be 666, 491, and 622 mm in 1992, 1993, and 1994, respectively.

Treatment irrigation criteria	Irrigation intensity	1992 Total water applied	1992 Avg soil water potential[z]		1993 Total water applied	1993 Avg soil water potential		1994 Total water applied	1994 Avg soil water potential	
			0.2 m	0.5 m		0.2 m	0.5 m		0.2 m	0.5 m
kPa	% of ET_c	mm	kPa	kPa	mm	kPa	kPa	mm	kPa	kPa
–60	100	589	–50	–72	466	–30	–45	544	–37	–91
–80	100	566	-64	–75	255	–41	–67	380	–54	–99
–80	70	411	–58	–77	259	–51	–81	356	–59	–118
–80	50,70,50[y]	368	–72	–86	64	–63	–82	327	–60	–138
$LSD_{0.05}$		46	22	NS	39	14	25	70	17	37

[z]Average of daily 8:00 AM measurements from 5 plots, recorded a few days before tuber set through 7 Sept. each year.
[y]50% of accumulated ET_c replaced until tuber set, then 70% of ET_c replaced for six weeks, then 50% of ET_c replaced until last irrigation.
[NS]Nonsignificant.

Received for publication 7 Mar. 2002. Accepted for publication 17 Oct. 2002. Oregon State Univ. technical paper no. 11869. We thank the Oregon Potato Commission, the Oregon Dept. of Agriculture, the Oregon Dept. of Environmental Quality, and E.P.A. 319 funds for financial support for this study. Use of trade names does not imply endorsement of the products named nor criticism of similar ones not named.
[1]Professor.
[2]Senior Faculty Research Assistant.
[3]Biological Sciences Research Technician.
[4]Senior Faculty Research Assistant.

no more water applied than the accumulated evapotranspiration (ET_c) since the last irrigation. The deficit irrigation treatments had a percentage of the accumulated ET_c applied at each irrigation: 1) nearly 100%; 2) 70%; and 3) 50% until tuber set, then 70% for six weeks, and 50% thereafter. To reduce the risk of water movement below the top 0.3 m of soil, water applications at each irrigation were limited to avoid exceeding the water holding capacity of the soil to a 0.3 m depth. Individual water applications did not exceed 30 mm for the check treatment and 35 mm for the other treatments.

Irrigation scheduling was by soil water potential at a 0.2 m depth. When the average soil water potential reached –60 kPa for the check treatment and –80 kPa for the other treatments, all plots in the respective treatment were irrigated. Plots were irrigated individually as necessary. The level of –60 kPa for the check treatment was based upon previous research (Eldredge et al., 1992, 1996; Holder and Cary, 1984; Shock et al., 1992; van Loon, 1981). The level of –80 kPa for the other treatments was based on previous research showing that even a brief exposure to this soil water potential during tuber bulking could reduce 'Russet Burbank' tuber grade and quality (Eldredge et al., 1992, 1996).

Soil water potential was measured in each plot by two granular matrix sensors (GMS; Watermark Soil Moisture Sensors model 200SS; Irrometer Co., Riverside, Calif.) at the 0.2 m depth and two GMS at the 0.5 m depth. The GMS were offset 0.15 m from the hill center (Stieber and Shock, 1995). Sensor readings were calibrated to soil water potential (Eldredge et al., 1993). The GMS were read at 8:00 AM daily starting a few days before tuber set each year. Irrigation treatments were initiated no sooner than one week before tuber set each year (Cappaert et al., 1994; Shock et al., 1992).

Crop ET_c was estimated using a modified Penman equation (Wright, 1982) with data from an AgriMet (U.S. Bureau of Reclamation, Boise, Idaho) weather station at the experimental site. Crop ET_c was estimated and recorded from crop emergence until the final irrigation. Growing degree days (10 to 30 °C) were measured by a model TA 51 Omnidata degree day accumulator (Omnidata International, Logan Utah). The accumulated growing degree days during the tuber bulking period (10 June 10 to 24 Aug.) were 931, 695, and 946 °D for 1992, 1993, and 1994, respectively. Precipitation from emergence to harvest was 45, 55, and 23 mm for 1992, 1993, and 1994, respectively.

Main plots were 13 rows wide (12 m) and 12 m long. The cultivars were planted in the middle 7 rows of each 13 row plot. Performance of a seventh unnamed cultivar is not reported. Each plot was irrigated using sprinkler heads adjusted to cover a 90° angle at each corner of the plot. Water application rate was 10 mm/h. The coefficient of uniformity for the sprinkler system with 90° angle sprinklers at each corner of every plot, calculated according to Christiansen (1942) was 86%.

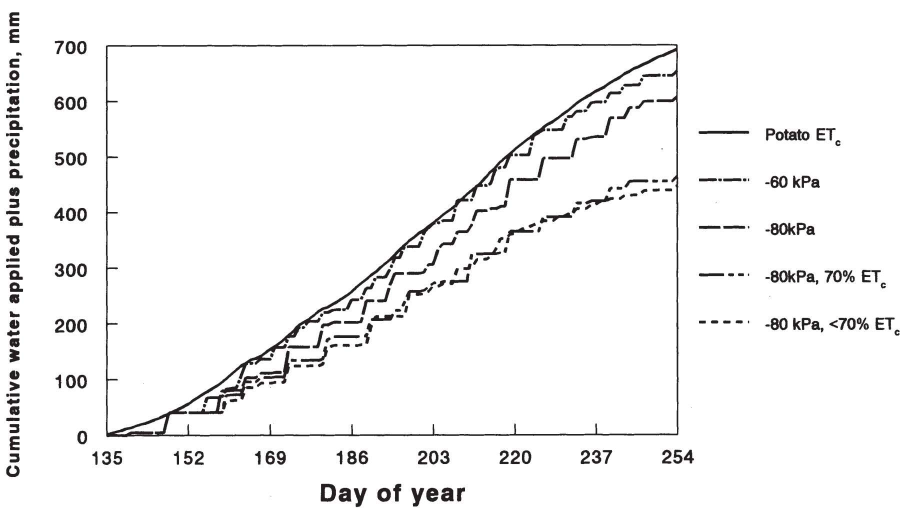

Fig. 1. Cumulative ET_c and water applied plus rainfall for potatoes submitted to four irrigation treatments in 1992. Treatment 1 was irrigated at -60 kPa and had a target of 100% of ET_c applied. Treatments 2, 3, and 4 were irrigated at –80 kPa and had targets of 100%, 70%, and <70% of ET_c applied, respectively. Data for 1993 and 1994 were similar.

Table 2. Tuber yield, tuber size distribution and tuber internal quality for six cultivars averaged over four irrigation treatments and 3 years.

Cultivar	Total yield	U.S. No. 1 yield	U.S. No 1 and U.S. No. 2 by tuber size: Small <113 g	Medium 113–283 g	Large >283 g	Fry color	Specific gravity
	--- $Mg\cdot ha^{-1}$ ---		------------------- % ------------------			% reflectance	g/cm^3
1992							
Russet Burbank	64.3	32.3	21.1	32.6	33.1	35.3	1.083
Shepody	62.9	50.0	10.9	27.2	52.4	49.8	1.091
Frontier Russet	51.1	41.6	17.2	31.8	35.2	38.3	1.083
Ranger Russet	59.6	45.6	13.5	26.6	49.1	43.3	1.100
Umatilla Russet	69.3	56.4	17.7	32.9	37.6	43.7	1.096
Russet Legend	58.9	48.2	10.5	26.1	56.2	48.1	1.088
Mean	61.0	45.7	15.2	29.5	43.9	43.1	1.090
1993							
Russet Burbank	57.5	39.3	29.8	35.3	15.7	40.1	1.090
Shepody	45.8	35.0	11.0	27.6	56.3	46.9	1.089
Frontier Russet	40	28.2	21.1	33.0	28.3	39.2	1.091
Ranger Russet	40.9	26.0	31.1	33.1	11.7	44.3	1.101
Umatilla Russet	47.8	34.0	17.0	34.0	39.1	45.1	1.093
Russet Legend	50.7	33.6	7.9	27.3	61.4	50.3	1.097
Mean	47.1	32.7	19.7	31.7	35.4	44.3	1.094
1994							
Russet Burbank	54.5	18.4	28.0	26.8	8.9	28.2	1.075
Shepody	48.7	27.5	22.0	36.4	26.2	44.7	1.093
Frontier Russet	47.9	38.0	22.3	40.1	23.2	41.6	1.086
Ranger Russet	51.9	31.7	31.5	31.2	9.7	44.3	1.095
Umatilla Russet	49.3	31.1	27.7	33.4	17.5	46.0	1.087
Russet Legend	51.2	39.7	15.4	36.8	38.1	46.3	1.085
Mean	50.6	31.1	24.5	34.1	20.6	41.9	1.087
All years							
Russet Burbank	58.8	30.0	26.3	31.6	19.2	34.5	1.083
Shepody	52.5	37.5	14.6	30.4	45.0	47.1	1.091
Frontier Russet	46.3	35.9	20.2	35	28.9	39.7	1.087
Ranger Russet	50.8	34.4	25.4	30.3	23.5	44.0	1.100
Umatilla Russet	55.5	40.7	20.8	33.4	31.4	44.9	1.094
Russet Legend	53.6	40.5	11.3	30.1	51.9	48.2	1.090
Mean	52.9	36.5	19.8	31.8	33.3	43.0	1.091
$LSD_{0.05}$ Cult.	2.5	2.6	1.6	2.1	2.8	1.3	0.005
$LSD_{0.05}$ Y	1.8	1.9	1.2	1.5	2.0	NS	NS
$LSD_{0.05}$ Y × C	4.3	4.5	2.9	3.6	4.9	2.3	NS
F values							
Cultivar (C)	24.1***	19.87***	100.16***	7.00***	161.72***	134.87***	8.71***
Year (Y)	20.44**	19.98***	17.29***	5.89*	37.33***	4.32	4.55
Y × C	6.26***	19.66***	17.72***	10.21***	26.88***	13.22***	1.49

NS, *, **, ***Nonsignificant or significant at $P < 0.05$, 0.01, or 0.001, respectively.

The insecticide phorate at 3.4 kg·ha^{-1} was applied together with the pre-emergence urea in early May. The herbicides pendimethalin and metolachlor were broadcast at 1.12 kg·ha^{-1} and 2.24 kg·ha^{-1}, respectively, in mid May, and incorporated immediately with a Lilliston Rolling Cultivator (Bigham Brothers, Lubbock, Texas).

Tubers were harvested from the middle 9 m of one 12-m long row for each cultivar in each main plot in early October each year. Tubers were graded by market class (U.S. No. 1 and U.S. No. 2) and size (small:113 to 170 g, medium:170 to 283 g, and large: >283 g). Tubers were graded as U.S. No. 2 if any of the following conditions existed: growth cracks, bottleneck shape, abnormally curved shape, or two or more knobs.

A representative 20-tuber subsample from every cultivar in every main plot was put in storage (8 °C, 90% relative humidity) until early November when tuber specific gravity and stem-end fry color were determined. Tuber fry color was determined according to the methodology described by Shock et al. (1994).

The response of tuber yield, tuber size distribution, and tuber internal quality to cultivars and years were evaluated by analysis of variance with the general linear model procedure (NCSS, Kaysville, Utah). The response of tuber yield and U.S. No. 1 yield to total water applied (irrigation plus precipitation) were evaluated by regression analysis with the response surface regression procedure (NCSS).

Results and Discussion

Water applications over time for all treatments were close to and less than the target ET_c values each year (Table 1; Fig. 1). In every year of the study, the average soil water potential at 0.5 m depth was lower than at 0.2 m depth for all treatments and total water applied was less or slightly less than the estimated ET_c (Table 1), suggesting that nitrate leaching potential was minimal. Irrigation scheduling, using both a target soil water potential and controlled water applications that did not exceed the water holding capacity of the top 0.3 m of soil, resulted in total seasonal applied water being slightly less than estimated ET_c, even when the crop was irrigated at –60 kPa. The water deficit can be partly supplied from stored soil water at lower depths. In addition, water savings were accrued by initiating irrigations only after full emergence and early vegetative growth (Shock et al., 1992).

Year, cultivar, and the interaction of year by cultivar significantly influenced total yield and U.S. No. 1 yield (Table 2). 'Russet Burbank' was the least productive cultivar in U.S. No. 1 yield in 1992 and 1994 and the most productive of U.S. No. 1 yield in 1993.

In 1992, 'Umatilla Russet' had a strong positive response to applied water for total and U.S. No. 1 yield and was the most productive cultivar in total and U.S. No. 1 yield (Fig. 2). In 1992, tuber yield decreased with decreases in applied water. Total yield response to applied water for 'Russet Burbank' and total and U.S. No. 1 yield response to applied water for 'Russet Legend' were nonsignificant. 'Russet Legend' was as productive of U.S. No. 1 yield over most of the range of applied water as 'Shepody', 'Frontier Russet', and 'Ranger Russet' were at the higher end of the applied water range.

In 1993, only 'Russet Burbank' showed a positive response for total yield to the range of applied water (Fig. 3) and was the most productive of total yield (Table 2). 'Russet Burbank', 'Shepody', 'Umatilla Russet' and 'Russet Legend' had similar productivity of U.S. No. 1 tubers. The lack of tuber yield responsiveness to applied water in 1993 was probably related to the unusual cool and wet weather during the tuber bulking period (10 June to 24 Aug.), cooler and wetter than in either 1992 or 1994 or the historic average for that period.

In 1994, all cultivars showed linear increases in both total and U.S. No. 1 yield with increases in water applied except 'Russet Burbank' and 'Russet Legend' (Fig. 4). 'Russet Burbank' U.S. No. 1 yield was maximized at 27 Mg·ha^{-1} by 565 mm of applied water. 'Russet Legend' total and U.S. No. 1 yield were maximized at 61 and 52 Mg·ha^{-1} by 539 and 540 mm of applied water, respectively. These maximum yields for 'Russet Legend' were similar to maximum yields for 'Frontier Russet', 'Ranger Russet', and 'Umatilla Russet' at slightly higher levels of applied water. Total yields of all the other cultivars except 'Russet Legend', increased at the higher water application rates. 'Umatilla Russet' had a high regression coefficient for applied water vs. total yield.

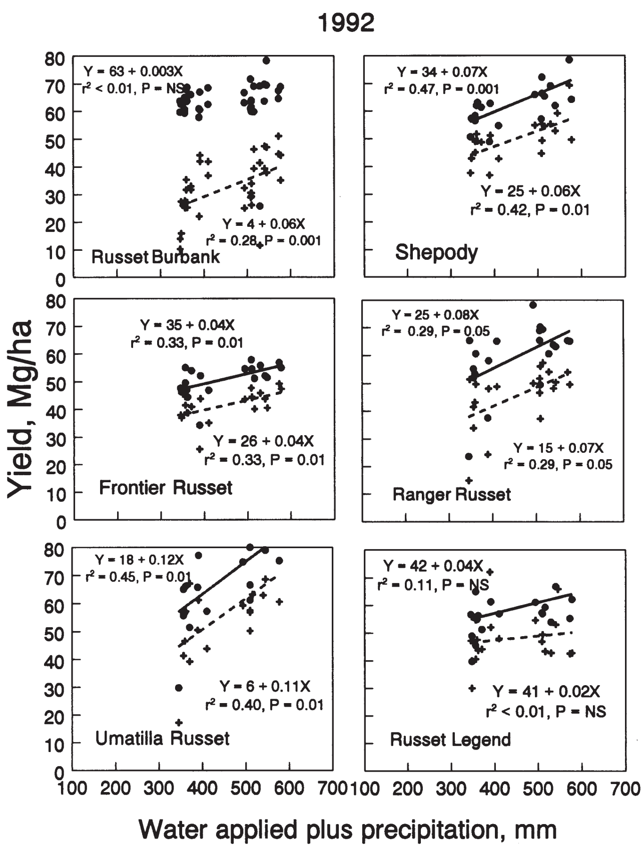

Fig. 2. Potato cultivar yield response to irrigation plus precipitation in 1992. Total yield (•) solid line, U.S. No. 1 yield (+) dashed line.

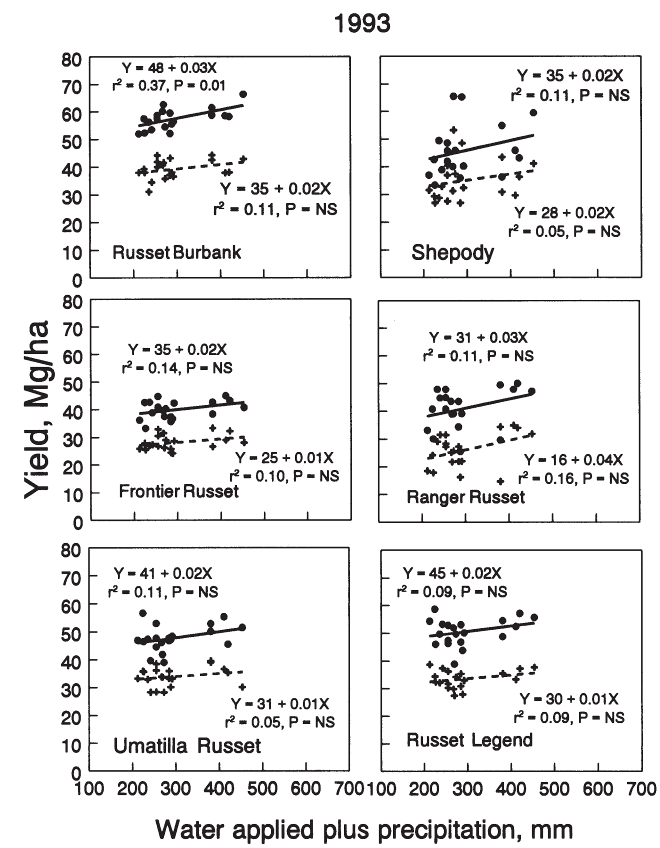

Fig. 3. Potato cultivar yield response to irrigation plus precipitation in 1993. Total yield (•) solid line, U.S. No. 1 yield (+) dashed line.

Averaged over the three years, 'Umatilla Russet' had a high regression coefficient for applied water vs. U.S. No. 1 yield and was the most productive of U.S. No. 1 yield. 'Russet Burbank' and 'Umatilla Russet' were the most productive in total yield when irrigated at full ET_c. Averaged over the three years, total yields of all cultivars except 'Russet Burbank' and 'Russet Legend' increased with increases in applied water (Fig. 5). 'Russet Burbank' produced relatively few U.S. No. 1 tubers and 'Russet Burbank' U.S. No. 1 yield was maximized at 34 $Mg\cdot ha^{-1}$ by 457 mm of applied water. Both total and U.S. No. 1 yield response to applied water for 'Russet Legend' were nonsignificant. However, 'Russet Legend' was as productive of U.S. No. 1 yield over most of the range of applied water as 'Shepody', 'Frontier Russet', and 'Ranger Russet' were at the full irrigation end of the applied water range.

'Russet Burbank' had the highest total yield when averaged over irrigation treatments and over the three years (Table 2). 'Umatilla Russet' and 'Russet Legend' had the highest U.S. No. 1 yield when averaged over irrigation treatments and years.

Averaged over the 3 years and over the irrigation treatments, 'Russet Legend' had the highest proportion of large tubers followed by 'Shepody' (Table 2). These large tubers (>283 g) are less desirable for processing into frozen French fries (a contract disincentive) because of losses in processing due to excessively long fry strip length. 'Umatilla Russet' had about the same proportion of tubers in the medium and large categories. 'Russet Burbank' and 'Ranger Russet' had the largest proportions of undersized tubers <113 g. 'Frontier Russet' and 'Umatilla Russet' were among the cultivars with the highest proportion of medium tubers considered ideal for processing. There were no significant differences between cultivars in tuber size response to applied water.

Averaged over the three years and over the irrigation treatments, 'Russet Legend' and 'Shepody' had the lightest frying tubers, followed by 'Umatilla Russet' and 'Ranger Russet' (Table 2). 'Ranger Russet' had the highest specific gravity followed by 'Umatilla Russet', 'Russet Legend', and 'Shepody'. Tuber specific gravities for 'Umatilla Russet', 'Russet Legend', 'Ranger Russet', and 'Shepody' were in the very high category (>1.089 $g\cdot cm^{-3}$) according to Mosley and Chase (1993). Neither tuber stem-end fry color nor tuber specific gravity were responsive to applied water in this study.

Short term deficit irrigation intensities (percent of ET_c replaced) in this study were within the ranges that resulted in dark stem-end fry color and losses in tuber specific gravity in other studies (Eldredge, et al., 1996; Shock, et al., 1993). The lack of stem-end fry color response or consistent losses in tuber specific gravity to the season-long deficit irrigation in this study indicates that the potato plants could have become somewhat drought hardened in the manner hypothesized by van Loon (1981). Well watered potato subjected to irrigation deficits during tuber bulking have been shown to respond with reduced specific gravity (Eldredge et al., 1996; Hang and Miller, 1986; Martin and Miller, 1983; Miller and Martin, 1987b; Stark and McCann, 1992). Miller and Martin (1987a) found that specific gravity of 'Russet Burbank' was reduced by deficit irrigation at 80% of ET_c on a sandy soil. Stark and McCann (1992) reported that specific gravity was reduced and stem-end fry color was darker for 'Russet Burbank' subject to deficit irrigation at 80% of ET_c on a silt loam soil. In the study reported here, stress levels repeated all season and irrigations were managed to maintain root zone SWP higher than –80 kPa, thus attenuating the intensity of water stress resulting from the deficit irrigation treatments. The aforementioned studies, despite using daily irrigations, did not use SWP feedback for irrigation scheduling.

These results indicate that 'Russet Legend' was the only cultivar showing a tolerance to deficit irrigation. In 2 out of the 3 years, 'Russet Legend' was as productive of U.S. No. 1 yield over most of the range of applied water when compared to 'Shepody', 'Frontier Russet', and 'Ranger Russet' at the higher end of the applied water range. The new cultivars 'Umatilla Russet' and 'Russet Legend' performed as well as or better than the established commercial cultivars at full irrigation, with 'Umatilla Russet' showing a higher yield potential at the higher water application rates than 'Russet Legend'. All cultivars produced more U.S. No. 1 tubers than 'Russet Burbank' in 1992 and 1994. 'Russet Burbank' performed well in 1993, an unusually cool and wet year.

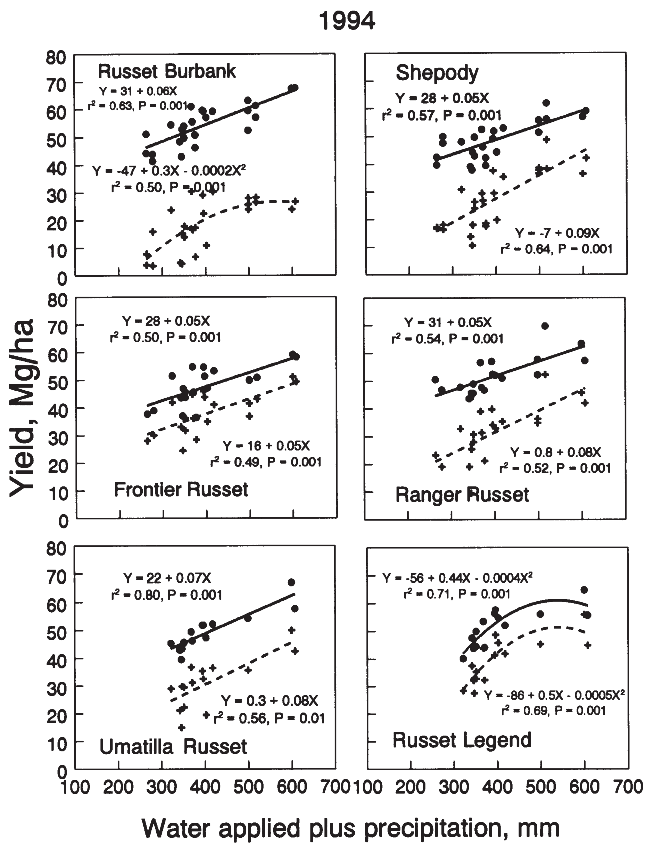

Fig. 4. Potato cultivar yield response to irrigation plus precipitation in 1994. Total yield (•) solid line, U.S. No. 1 yield (+) dashed line.

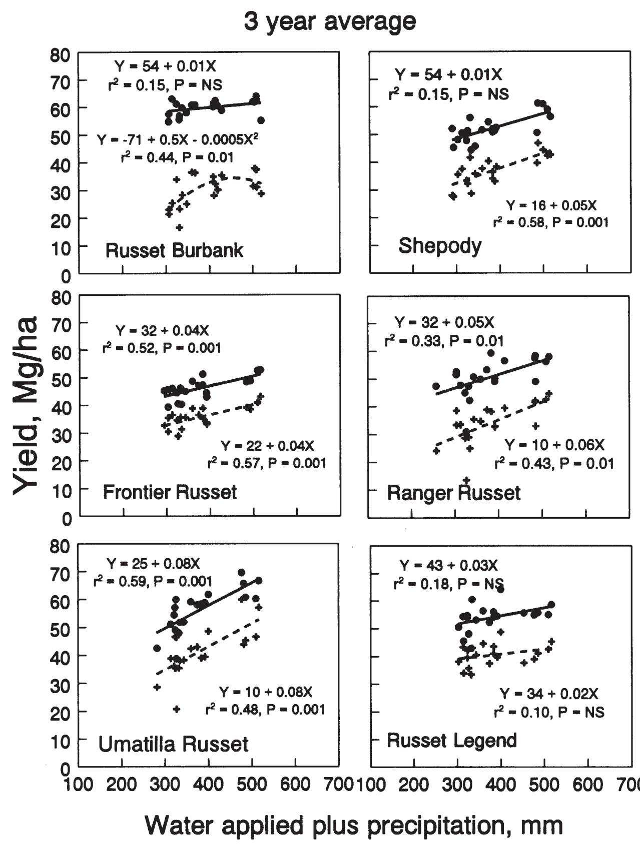

Fig. 5. Potato cultivar yield response to irrigation plus precipitation averaged over three years. Total yield (•) solid line, U.S. No. 1 yield (+) dashed line.

Literature Cited

Cappaert, M.R., M.L. Powelson, N.W. Christensen, W.R. Stevenson, and D.I. Rouse. 1994. Assessment of irrigation as a method of managing potato early dying. Phytopathology. 84:792–800.

Christiansen, J.E. 1942. Irrigation by sprinkling. California Agr. Expt. Sta. Bul. 670.

Eldredge, E.P., Z.A. Holmes, A.R. Mosley, C.C. Shock, and T.D. Stieber. 1996. Effects of transitory water stress on potato tuber stem-end reducing sugar and fry color. Amer. Potato J. 73:517–530.

Eldredge, E.P., C.C. Shock, and T.D. Stieber. 1993. Calibration of granular matrix sensors for irrigation management. Agron. J. 85:1228–1232.

Eldredge, E.P., C.C. Shock, and T.D. Stieber. 1992. Plot sprinklers for irrigation research. Agron. J. 84:1081–1084.

Hang, A.N. and D.E. Miller. 1986. Yield and physiological responses of potatoes to deficit, high frequency sprinkler irrigation. Agron. J. 78:436–440.

Holder, C.B. and J.W. Cary. 1984. Soil oxygen and moisture in relation to Russet Burbank potato yield and quality. Amer. Potato J. 61:67–75.

Jefferies, R.A. and D.K.L. MacKerron. 1993a. Responses of potato genotypes to drought. I. Expansion of individual leaves and osmotic adjustment. Ann. Appl. Biol. 122:93–104.

Jefferies, R.A. and D.K.L. MacKerron. 1993b. Responses of potato genotypes to drought. II. Leaf area index, growth and yield. Ann. Appl. Biol. 122:105–112.

Lynch, D.R. and G.C.C. Tai. 1989. Yield and yield component response of eight potato genotypes to water stress. Crop Science 29:1207–1211.

Lynch, D.R., N. Foroud, G.C. Kozub, and B.C. Farries. 1995. The effect of moisture stress at three growth stages on the yield components of yield and processing quality of eight potato cultivars. Amer. Potato J. 72:375–386.

Martin, M.W. and D.E. Miller. 1983. Variations in responses of potato germplasm to deficit irrigation as affected by soil texture. Amer. Potato J. 60:671–683.

Miller, D.E. and M.W. Martin. 1987a. The effect of irrigation regime and subsoiling on yield and quality of three potato cultivars. Amer. Potato J. 64:17–26.

Miller, D.E. and M.W. Martin. 1987b. Effect of declining or interrupted irrigation on yield and quality of three potato cultivars grown on sandy soil. Amer. Potato J. 64:109–118.

Mosley, A.R., S.R. James, D.C. Hane, K.A. Rykbost, C.C. Shock, B.A. Charlton, J.J. Pavek, S.L. Love, D.L. Corsini, and R.E. Thornton. 2000a. Umatilla Russet: A full season long russet for processing and fresh market use. Amer. J. Potato Res. 77:83–87.

Mosley, A.R., S.R. James, C.C. Shock, D.C. Hane, K.A. Rykbost, B.A. Charlton, D.G. Holm, S.L. Love, D.L. Corsini, J.J. Pavek, and R.E. Thornton. 2000b. Russet Legend: A full season long russet for processing and fresh market use. Amer. J. Potato Res. 77:77–81.

Mosley, A.R., and R.W. Chase. 1993. Selecting cultivars and obtaining seed lots. p. 19–27. In: Randall C. Rowe (ed.). Potato health management. APS Press, St. Paul, Minn.

Schaible, G.D., N.R. Gollehon, M.S. Kramer, M.P. Aillery, and M.R. Moore. 1995. Economic analysis of selected water policy options for the Pacific Northwest. U.S. Dept. Agr. Econ. Rpt. 720.

Shock, C.C., J.C. Zalewski, T.D. Stieber, and D.S. Burnett. 1992. Impact of early-season water deficits on Russet Burbank plant development, tuber yield and quality. Amer. Potato J. 69: 793–803.

Shock, C.C., Z.A. Holmes, T.D. Stieber, E.P. Eldredge, and P. Zhang. 1993. The effect of timed water stress on quality, total solids and reducing sugar content of potatoes. Amer. Potato J. 70: 227–241.

Shock, C.C., T.D. Stieber, J.C. Zalewski, E.P. Eldredge, and M.D. Lewis. 1994. Potato tuber stem-end fry color determination. Amer. Potato J. 71:77–88.

Stark, J.C., and I.R. McCann. 1992. Optimal allocation of limited water supplies for Russet Burbank potatoes. Amer. Potato J. 69:413–421.

Stieber, T.D., and C.C. Shock. 1995. Placement of soil moisture sensors in sprinkler irrigated potatoes. Amer. Potato J. 72:533–543.

van Loon, C.D. 1981. The effect of water stress on potato growth, development, and yield. Amer. Potato J. 58:51–69.

Wright, J.L. and J.C. Stark. 1990. Potato. p. 859–888. In: (B.A. Stewart and D.R. Neilsen). Irrigation of Agricultural Crops- Agron. Monogr. no. 30, ASA-CSSA-SSSA, Madison, Wisc.

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