EFFECT OF IRRIGATION REGIME AND SUBSOILING ON YIELD AND QUALITY OF THREE POTATO CULTIVARS GROWN ON SANDY SOIL

by
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Potatoes require a relatively high level of soil water for optimum yield and quality, especially between tuber initiation and maturity. In the northwestern United States, considerable research has been done to determine the effect of water stress on potato production, primarily with the Russet Burbank cultivar. Water stress has not greatly influenced tuber yield of this cultivar, but it has markedly increased the number of malformed tubers (Painter and Augustine, 1976; Ibrahim, 1985; Miller and Martin, 1987a, 1987b). Many potatoes produced in the Northwest are grown on sandy soils under sprinkler irrigation. The low water holding capacity and restricted rooting often associated with these soils create conditions where water stress injury is likely, especially if the irrigation system temporarily fails. Quality of the stress-sensitive cultivar Russet Burbank is often severely reduced by such a water shortage. Nooksack and Lemhi have not been tested under such conditions.

Another common problem on coarse-textured soils that affects plant-water relations is that of soil compaction. The compaction is often due to excessive equipment travel. Compact layers restrict root growth and reduce the amount of water and nutrients plants can obtain. Subsoiling has been effective in loosening hard layers, increasing deeper rooting, and reducing water stress between irrigations (Ibrahim, 1985; Miller and Martin, 1987b).

Martin and Miller (1983) found that Nooksack and Lemhi cultivars have the potential for performing well under adverse soil water conditions. In 1984 and 1985, studies were conducted to evaluate the ability of Nooksack and Lemhi to tolerate water stress brought about by various combinations of irrigation regimes and subsoiling. These studies were conducted on a deep Quincy sand on the Prior Land Company farm near Paterson, Washington.

PROCEDURES

Effect of declining or interrupted irrigation

A study was conducted to compare the responses of Russet Burbank, Nooksack, and Lemhi cultivars to interruptions in irrigation at the time of either tuber initiation (early July) or tuber bulking (late July). Detailed reports of this work have been given by Martin and Miller, 1986; and Miller and Martin, 1987a).

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Irrigation treatments were to sprinkle irrigate every day at rates determined by evaporation pan (treatment 1) except for a period of 10 days without irrigation at about tuber initiation (treatment 2) or during tuber bulking (treatment 3). Following a no-irrigation period, 2 inches of water were applied and irrigation thereafter was the same as for treatment 1. Tubers were harvested on September 25, 1984, and September 5, 1985. The early 1985 harvest was necessary because of early dying attributed to Verticillium dahlae.

Effect of irrigation regime and subsoiling.

Two non-replicated irrigation regimes, daily irrigation or irrigation every 4 days, were established about 7 weeks after planting. The same total amounts of water were applied in both regimes, and these were determined by evaporation pan. Subplots within each irrigation treatment were no subsoiling and subsoiling to a depth of about 36 inches with subsoiler shanks 23 inches apart. Subsoiling was perpendicular to the direction of planting. Tubers were harvested on October 3, 1985.

Just before harvest the soil was thoroughly irrigated to minimize the effect of soil water content on soil strength. A few days later soil strength was measured at several locations within the center row of each plot, using a hand-held recording penetrometer.

RESULTS AND DISCUSSION

Effect of declining or interrupted irrigation

There were marked differences among cultivars in total tuber yield (Table 1A). Averaged over all treatments, Russet Burbank was the highest yielding cultivar (19.7 t/ac) while Nooksack and Lemhi were somewhat lower (16.5 and 17.2 t/ac, respectively). Both interruptions in irrigation (treatments 2 and 3) reduced yields of Russet Burbank and Lemhi. Nooksack showed similar trends but differences were not significant.

Irrigation treatment had no effect on number of tubers (Table 1B), but the percentage by weight of undersized tubers (less than 4 oz) increased and average tuber weight decreased in the stressed treatments compared to full irrigation, except for Nooksack (Tables 1C and 1D). In Russet Burbank, 30 to 40% of the tubers were undersize when water was withheld at either tuber initiation or bulking. Nooksack tuber size was not affected by irrigation treatment.

There were major differences among the cultivar's response to water stress in terms of percent U.S. No. 1 tubers (Table 1E). Russet Burbank suffered a much greater decrease in % U.S. No. 1 tubers with interrupted irrigation than did Nooksack or Lemhi. Withholding water from Russet Burbank during tuber initiation resulted in only 10% of the tubers being graded U.S. No. 1. Nooksack was not significantly affected by water stress, and Lemhi was affected only by the late interruption.

Nooksack had the highest specific gravity and Russet Burbank had the lowest (Table 1F). The specific gravity of all cultivars was reduced by interrupting irrigation.

The percent of tubers with external defects increased with water stress in Russet Burbank, but Nooksack and Lemhi were unaffected by irrigation treatment (Table 1G).

Effect of irrigation regime and subsoiling

There were visible growth responses to subsoiling. Plants on subsoiled plots were larger, and the canopy closed sooner than without subsoiling. After full cover there were no visible differences in foliage.

Soil strength is a term for the pressure needed to force a metal rod into the soil. This measurement has been related to the ability of roots to grow into the soil. A strength of about 2 to 3 MPa will restrict root growth (Taylor and Gardner, 1963; Taylor et al., 1966). Potato root growth may be reduced at strengths of about 1 MPa (Bishop and Grimes, 1978). Subsoiling markedly reduced soil strength (Fig. 1). If about 2 MPa is taken as limiting root growth, few roots would be expected deeper than about 0.3 m (1 ft) without subsoiling. Subsoiling resulted in negligible resistance to root growth. Root densities were not measured in this study, but Ibrahim (1985) found that subsoiling markedly increased root density in the 1- to 2-ft zone of this soil. Similar results would be expected in this study. The deeper rooting allowed plants to obtain sufficient water to avoid serious water stress between irrigations.

There were significant differences due to cultivars in almost every response category (Table 2). Usually Russet Burbank reacted differently from Nooksack and Lemhi, which were often similar. Russet Burbank was highest yielding and had the most tubers and the most malformed tubers. It also had the smallest tubers, the least with internal defects, and the lowest specific gravity.

The most important difference among the cultivar responses to the irrigation and tillage treatments was in % U.S. No. 1 tubers (Table 3). With subsoiling irrigation regime had little effect on this value, but without subsoiling % U.S. No. 1 tubers was much lower with a 4-day irrigation interval than with daily irrigation. Russet Burbank was affected much more than the other cultivars. Even with daily irrigation, a restricted root system (no subsoiling) apparently allowed water stress to develop, and only about 17% of the Russet Burbank tubers graded U.S. No. 1. The expanded root system allowed by subsoiling increased this to nearly 60%.

Benefits of subsoiling may not be adequate to justify the expense, except in the production of Russet Burbank, especially if a reliable high-frequency irrigation system is available. However, the cost of subsoiling can be spread out over several years.

Soil strengths at the end of 1986, three growing seasons after subsoiling in 1984, were similar to those shown. Therefore, low soil strengths should persist for several years if recompaction by equipment is prevented. Subsoiling does offer some degree of insurance against water stress injury in the event of a temporary failure in the irrigation system.

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Table 1. Response of three potato cultivars to water-stress inducing irrigation treatment. 1984 and 1985.

	Irrigation Treatment[1]			
	1	2	3	Ave.
A. Total tuber yield, tons/acre				
Russet Burbank	24.1a[2]	18.3b	16.8b	19.7a[3]
Nooksack	18.3a	16.3a	15.0a	16.5b
Lemhi	20.3a	17.2ab	14.2b	17.2b
Average	20.			
9a 17.3b	15.3c			
B. Number of tubers, thousands/acre				
Russet Burbank	140a	145a	142a	142a
Nooksack	96a	104a	97a	99b
Lemhi	90a	100a	106a	99b
Average	109a	116a	115a	
C. Tubers<4 oz., % by weight				
Russet Burbank	19b	32a	42a	31a
Nooksack	14a	23a	19a	19b
Lemhi	12b	18b	31a	20b
Average	15b	24a	31a	
D. Average tuber weight, ounces				
Russet Burbank	5.9a	4.1b	3.7b	4.6b
Nooksack	6.0a	5.0a	5.1a	5.4a
Lemhi	7.8a	5.5b	4.3b	5.9a
Average	6.6a	4.9b	4.4b	
E. U.S. No. 1 tubers, % by weight				
Russet Burbank	48a	10b	18b	25b
Nooksack	67a	54a	60a	60a
Lemhi	74a	60ab	52b	62a
Average	63a	42b	44b	
F. Specific gravity of U.S. No. 1 tubers				
Russet Burbank	1.077a	1.072b	1.071b	1.073c
Nooksack	1.088a	1.084ab	1.081b	1.084a
Lemhi	1.083a	1.077b	1.076b	1.079b
Average	1.083a	1.077b	1.076b	

Table 1 (continued)

G. Tubers with external defects, % of total tubers

Russet Burbank	29b	40a	24b	31a
Nooksack	16a	18a	15a	16b
Lemhi	12a	12a	10a	11c
Average	19a	24b	16a	

[1] 1. Full irrigation to replace estimated ET each day.

2. Full irrigation except no irrigation for 10 days during tuber initiation (July 3 to 13).

3. Full irrigation except no irrigation for a period during tuber bulking (July 20 to 27, 1984; July 19 to 29, 1985).

[2] Numbers within a row followed by different letters are significantly different at P = .05 by Duncan's multiple range test.

[3] Numbers within the average column in each category followed by different letters are significantly different by Duncan's multiple range test.

Table 2. Tuber characteristics of three potato cultivars, averaged over irrigation and subsoiling treatments. 1985.

	Russet Burbank	Nooksack	Lemhi
Total tuber weight, t/acre	31.6 a[1]	26.0b	27.1b
Number of tubers, thousands/acre	179a	93c	117b
Average tuber weight, oz	5.6b	8.9a	7.4a
Tuber external defects, %[2]	44a	21b	17b
Specific gravity	1.080b	1.088a	1.083b
Tuber internal defects, %[3]	22b	39a	31ab

[1] Numbers within a row followed by different letters are significantly different at P+ = .05, by Duncan's multiple range test.

[2] Based on total number of tubers.

[3] Tubers that graded U.S. No. 1 externally.

Table 3. Effect of irrigation regime and subsoiling on percent by weight of tubers grading U.S. No. 1 in three potato cultivars. 1985.

	% U.S. No. 1 Tubers					
Cultivar:	Russet Burbank		Nooksack		Lemhi	
Irrigation Regime:	Daily	4 days	Daily	4 days	Daily	4 days
	% by Weight					
Not subsoiled	17	10	76	60	77	54
Subsoiled	54**	58**	77	77+	80	77*

+, *, ** Subsoiled is significantly greater than not subsoiled at P = .10, 05, and .01, respectively.

Figure 1. Soil strength profiles for Quincy sand as affected by subsoiling, 1985. *, **, *** differences at a given depth due to subsoiling are significant at P = .05, .01, and .001, respectively.