PROSPECTS FOR MANAGING IRRIGATION WATER TO SUPPRESS POTATO EARLY DYING

by
Mary L. Powelson, Marlys R. Cappaert, and Neil W. Christensen
Departments of Botany and Plant Pathology and Crop and Soil Science, Oregon State University, Corvallis, Or. 97331

Premature vine death and declining yields are a long-standing problem in many areas where potatoes have been in production for many years. This syndrome, called potato early dying, occurs in both irrigated and nonirrigated production areas of the United States. It is especially important in the irrigation areas of the central, southern, and western United States. The soilborne fungus, Verticillium dahliae, is the primary cause of this disease in the different potato-growing areas of North America.

The most common disease symptoms -- chlorosis and necrosis of leaves followed by premature defoliation-- are indistinguishable from natural senescence. In diseased plants, however, the rate of senescence is accelerated. Advanced symptoms usually do not appear until the tuber-bulking stage and can occur 2 to 8 weeks prior to regional harvest.

The development of potato early dying is affected by abiotic factors such as temperature and moisture. Disease severity tends to increase as the mean air temperature rises from 20 to 28 C. If high temperatures prevail during the tuber bulking period, yields can be limited. Influence of soil moisture on development of potato early dying is rapidly becoming apparent. In irrigated potato systems, a factor that influences the development of this disease is amount of applied water. This aspect has been the focus of our research over the past 6 years.

In our initial studies with Russet Burbank we compared the combined effects of a range in both soil populations of Verticillium and amount of water applied by irrigation on disease severity and tuber yield. Ranges in amount of applied water were related to estimated consumptive use (ECU) by the plant. ECU is equal to evapotranspiration x a standard crop coefficient that is adjusted for crop stage. Potato early dying was consistently more severe under the excessive (150% ECU) than under the moderate (100% ECU) or deficit (50-75% ECU) irrigation regimes (Fig. 1). In addition, reductions in tuber yield were greater from plants grown in infested soil under the excessive compared to the moderate or deficit irrigation regimes (Fig. 2). Results of these early studies established that potato early dying is favored by relatively moist soil conditions.

This Presentation is part of the Proceedings of the 1994 Washington State Potato Conference & Trade Fair.

Fig. 1. Effects of inoculum density of Verticillium dahliae and irrigation regime on mean area under the senescence progress curve (AUSPC) of potato cultivar Russet Burbank grown in fumigated soil in Oregon field microplots in Crook County, 1988. Treatments are irrigation regime and inoculum density.

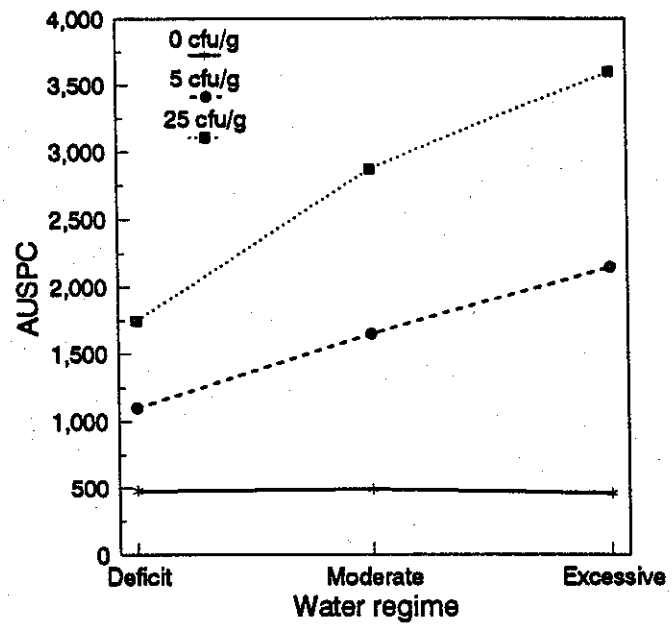
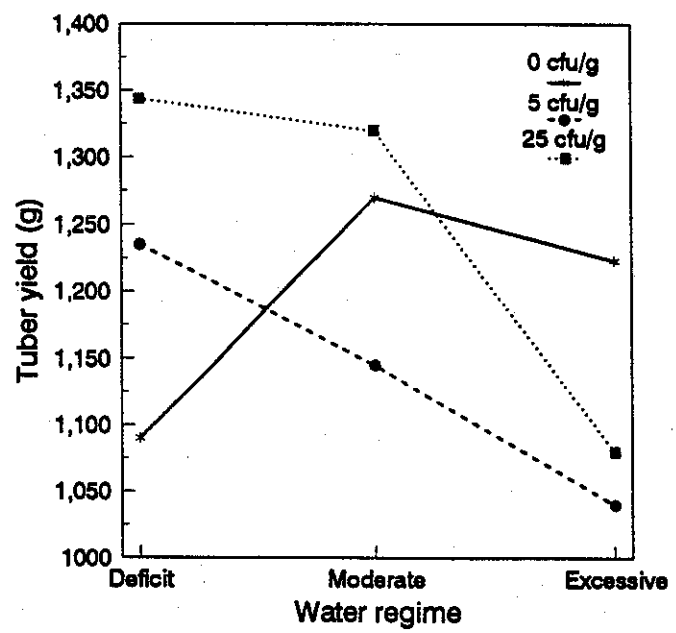


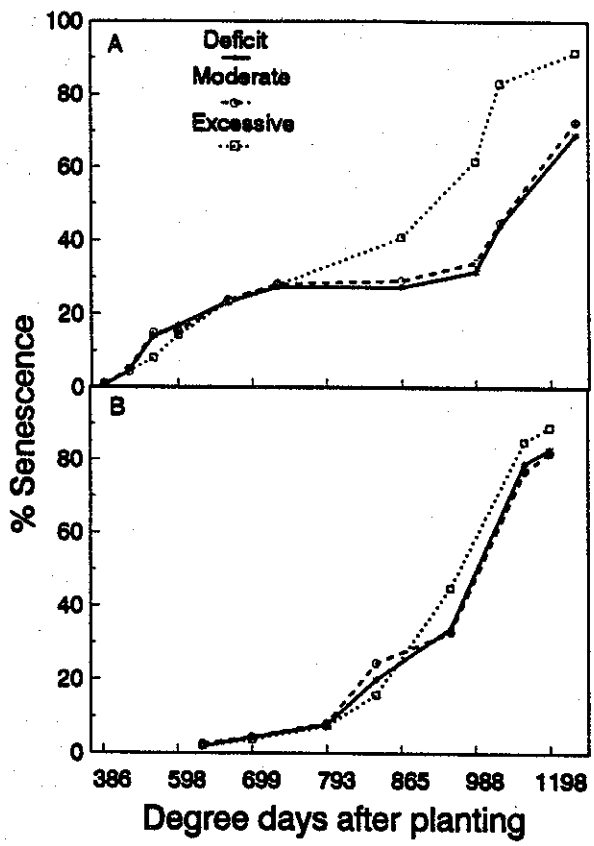
Fig. 2. Effects of inoculum density of Verticillium dahliae and irrigation regime on mean tuber yield, in grams, of potato cultivar Russet Burbank grown in fumigated soil in Oregon field microplots in Crook County, 1988. Treatments are irrigation regime and inoculum density.



Because water input after tuber initiation must remain optimal to prevent tuber malformation, water management prior to tuber initiation was the strategy we pursued. Field studies were conducted in 1991 and 1992 in the Columbia Basin of southcentral Washington to determine if amount of water applied between emergence and tuber initiation affected the severity of potato early dying and associated tuber yield. Amount of water applied to the moderate irrigation treatment approximated the ECU of the potato plant. The deficit and excessive irrigation treatments were approximately 50 or 150% ECU, respectively. During the treatment period, a total of 9.7, 18.1 or 27 cm of water was applied in 1991 and 13.6, 18.1. or 34.9 cm in 1992 for the deficit, moderate and excessive irrigation treatments, respectively. After tuber initiation, all plots were irrigated at 100% ECU.

Severity of potato early dying was significantly lower in the deficit compared to the excessive irrigation treatment (Fig. 3A and B). Areas under the senescence progress curve, a way to assess treatment effects, were 29.5 and 9.1% lower in the deficit compared to excessive early season treatments in 1991 and 1992, respectively.

Figure 3. Senescence progress curves for Russet Burbank potatoes grown in soil noninfested or infested with Verticillium dahliae, under three irrigation regimes, in field plots in A, 1991, and B, 1992. Data are for deficit, moderate, or excessive pre-tuberization irrigation regimes, which are below, equal to, or above ECU of the potato plant, respectively. Each datum point is the average of six plots.



Tuber yield was 17% higher in the deficit compared to the excessive early season irrigation treatments in 1991. In the excessive irrigation treatment, there was a significantly higher proportion of tubers in weight classes 1 and 2 (tubers < 170 g) and a significantly lower proportion of tubers in weight class 5 (285-397 g) compared the deficit irrigation treatment (Table 1). Irrigation regime had no significant effect on total tuber yield or specific gravity in 1992 (Table 2).

TABLE 1. Effect of irrigation treatment on tuber yield[u] of Russet Burbank potatoes in field plots in Washington, 1991

		Weight class (g)					
	Total (T/ha)	1 (1-113)	2 (114-170)	3 (171-284)	4[v] (171-397)	5 (285-397)	6 (>398)
Pretuberization irrigation regime[w]							
Deficit	61.9 a[x]	5.7 a	7.7 a	21.5 a	38.1 a	16.5 a	10.3 a
Moderate	66.8 a	5.5 a	7.5 a	21.2 a	39.8 a	18.6 b	13.9 a
Excessive	52.9 b	7.1 b	9.4 b	20.7 a	33.9 a	13.2 c	7.5 a

[u] Tuber yield is expressed in metric tons/ha.
[v] Weight class 4 represents the optimum tuber weight and is sum of weight classes 3 and 5.
[w] Pretuberization irrigation treatments were applied from plant emergence to tuber initiation. Deficit, moderate, and excessive irrigation treatments are relative to the estimated consumptive use by the plant.
[x] Means followed by the same letter are not significantly different at $P \leq 0.05$ according to LSD.

TABLE 2. Effect of irrigation treatments on tuber yield[v] and grade of Russet Burbank potatoes in field plots in Washington, 1992

			Weight class (g)			
	Total Yield (T/ha)	A's	4 (171-397)	B's	Culls	Specific gravity
Pretuberization irrigation regime[w]						
Deficit	48.9 a[x]	24.9 a	21.9 a	9.4 a	2.2 a	1.087 a
Moderate	56.9 a	28.8 a	26.3 a	11.8 a	2.4 a	1.068 a
Excessive	62.8 a	30.7 a	26.5 a	12.8 a	2.2 a	1.067 a

[v] Tuber yield is expressed in metric tons per ha.
[w] Pretuberization irrigation treatments were applied from plant emergence to tuber initiation. Deficit, moderate, and excessive irrigation treatments are relative to the estimated consumptive use by the plant.
[x] Means followed by the same letter are not significantly different at $P \leq 0.05$ according to LSD.

In the excessive irrigation treatment at 1000 degree days after planting, disease was 35% more severe in 1991 than 1992 which may explain, in part, the yield differences between treatments in 1991 but not 1992. In 1992, 6.2 cm of rain fell during the treatment period which may have negated the effect of irrigation treatment on tuber yield. Suppression of potato early dying by management of water early in the season may be feasible only in production areas and in seasons where there is a minimal spring rainfall.

In 1992 and 1993, nonreplicated irrigation treatments were established within commercial fields of Russet Burbank potatoes in Oregon's Columbia Basin to demonstrate to growers the effect of early season water management on suppression of potato early dying. Each circle contained two wedges that represented two irrigation regimes: irrigation decisions made by the grower (IDG) and irrigation decisions made by the researcher (IDR). The IDR was designed to equal ECU by the plant. The irrigation treatment period was from plant emergence to tuber initiation. Within each irrigation treatment, there were plots either infested or noninfested (control) with Verticillium.

In both years, symptoms of potato early dying (plots infested with the Verticillium) and those of normal plant senescence (control) developed more slowly in the IDR treatment than in the IDG treatment (Fig. 4A and B). The difference in amount of water applied between the IDR and IDG treatments was 8.9 and 3.8 cm for 1992 and 1993, respectively.

In summary, where Russet Burbank potatoes are grown under irrigation, the timing and amount of water can be managed to suppress potato early dying. The critical time is between emergence and tuber initiation. It is during this 4 wk period that soil moisture can be safely manipulated without jeopardizing tuber yield and quality. Conditions of lower soil water content (ca. 70-75% available soil moisture) during this time frame can reduce the rate of plant senescence. In addition to suppression of potato early dying, benefits to potato growers include cost of water and its application.

Figure 4. Effect of irrigation decision by grower (IDG) versus researcher (IDR) on severity of potato early dying in Russet Burbank potatoes in the Columbia Basin of Oregon in A, 1992 and B, 1993. Data for 1993 are average of two fields. Plots were either noninfested (=Control) or infested with 50 colony forming units of Verticillium dahliae per gram of soil (=Vert).