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Moapa Valley Surge Irrigation Study

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ABSTRACT

Surge irrigation was compared to conventional irrigation in 1995 in the Moapa Valley in southern Nevada. Irrigation trials were conducted on a basin-irrigated alfalfa field. Basins were equipped with surge valves, water meters, partial flumes and piezometers (groundwater depth measuring tubes) to evaluate the two irrigation systems. Water advance times to 1500 feet down the field were typically 90 minutes faster using surge irrigation. The irrigation time and irrigation volume was on the average 33% lower with surge irrigation, yet the soil moisture profiles were comparable. Although runoff did occur under both systems, an average 30% reduction in runoff was observed with the surge irrigated basins when compared with the conventional irrigated basins. Deep percolation was not estimated. However, soil salinity profiles at the end of the study suggest that reduced percolation did occur under the surge irrigation treatments. Although current water availability, water costs and surge equipment costs do not support the conversion to surge irrigation at this time, this technique should be revisited in the future when the water resource and economic picture changes.

SURGE IRRIGATION TECHNIQUE

Surge irrigation is a technique that involves the use of automatic valves to allow the pulsing of water down a furrow/basin. Conventional basin flood irrigation practices involve the application of water in a continuous stream. For a detailed description of how surge works, read C.D. Yonts et al. (1994a, 1994b), D.M. Cox (1994) and R. Bartholomay (1989). However, most applications of surge irrigation have been with furrow irrigation. Researchers believe that when irrigation water is stopped, soil particles are reoriented on the soil surface causing partial surface sealing. When water is reintroduced (second surge), infiltration is reduced in that portion of the field previously having water. The result is more water is available to advance down the field.

Research by Izuno et al. (1984) with furrow irrigation demonstrated that faster advance times (time water travels down field) could be achieved with surge irrigation when compared with a continuous application of water. Bartholomay and Brenner (1989) observed a 65 percent decrease in deep percolation of a furrow irrigated corn field when surge irrigation was compared to conventional irrigation. Such significant reductions in deep percolation (movement beyond the rootzone) were also shown by Bartholomay and Champion (1989) to lead to an average salt reduction of 4.6 tons per acre. Alam and Antonio (1992) quantified a combined salt load reduction in the lower Gunnison Basin of Colorado to be 2528 tons of salt during one summer under surge irrigation. Surge irrigation has also been shown to have no detrimental impact on crop yield. Miller et al. (1991) reported that the yield of wheat was equivalent under surge and conventional irrigation, even when surge irrigation provided only half the amount of water conventional irrigation provided. Economic analysis have indicated that surge irrigation can lead to greater profits on a dollar per acre basis, dependent on production costs and surge conversion costs (Wertz et al.l993).

FIELD METHODOLOGY

An alfalfa field was selected in the Moapa Valley to conduct a surge irrigation study. The soil type at the site was a Calico sandy loam. The field site was approximately 28 acres in size, with irrigation runs of approximately 1850 feet. A concrete lined irrigation ditch delivered water to the upper most part of the field. Gated 12 inch outlets were spaced every 75 feet. Each basin was approximately 225 feet wide containing 3 gated outlets. Four basins were selected for the study. Basins were separated by earthen dikes that were approximately 12 inches in height. Two adjacent surge irrigated basins were separated by 225 feet from two instrumented, conventional, flood-irrigated basins. Outlets in the surge basins were equipped with surge valves (one master valve and two slave valves per basin) that were operated with solar power. One outlet per treatment was also instrumented with a sparling flow meter to measure the volume of water entering the basin during each irrigation. The water in the irrigation ditch was maintained at a similar height by irrigating only one basin at a time (flow rates measured with the meter were similar for all irrigations). At the end of the field. a 12 to 18 inch dike connected adjacent basins of each treatment to a single 6 inch partial flume. The partial flumes were equipped with automatic recording devices that measured the volume of runoff. Each irrigation treatment had 3 piezometers (2 inch slotted pvc pipe with end cap) installed to a depth of 8 feet to monitor rises and falls in the water table. Piezometers were positioned 100 feet from the top of the field, at midfield and lQ0 feet from the bottom of the field. Measurements were taken with all instruments and monitoring devices just prior to and just after irrigation events. At the beginning and end of the study7 soil samples were taken to a depth of 4 feet in 8 inch increments. Soil samples were returned to the laboratory where the soil water contents and soil salinities were measured.

Irrigations occurred from late February to early November. During 1995, 15 irrigation events occurred. Time between irrigations ranged from as low as 6 days to as high as 34 days, with an average time between irrigations of 18 days. Surge irrigations involved closing outlets in one basin and opening outlets in the adjacent basin and then repeating this process until sufficient water was applied to advance the water to the end of the field. Surge times varied throughout the year as the number of surge irrigations and irrigation times were dictated by the distance the first two on/off events were able to advance the water. Typically 3 but sometimes 4 surge events were required, with a typical surge time being 50 minutes on and 50 minutes off.

FIELD RESULTS

Five surge and three conventional irrigation runs (out of the 15 total irrigation events) were closely monitored to determine the amount of time required for water to advance down the basins during an irrigation event (Figure 1).
In all five surge irrigations the advance time was faster than that observed with the conventional flood irrigation. The time required for water to advance to 1500 feet was on the average 94 minutes faster under surge irrigation. Nine of the 15 irrigation events were comparable. Lack of adequate water delivered to the field on several occasions and problems with surge controllers prevented a comparison of all 15 irrigation events. Based on the 9 comparable irrigations, surge irrigation reduced irrigation advance time from 17% to 45% with an average reduction of 33.2%.

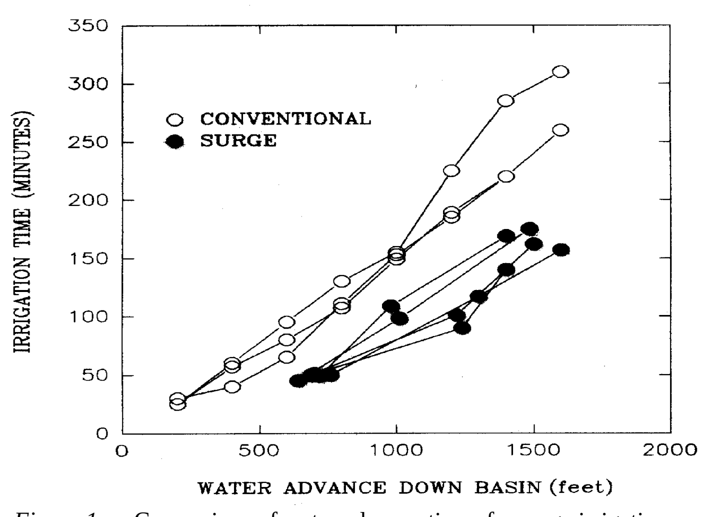

Figure 1. Comparison of water advance times for surge irrigation and conventional irrigation of alfalfa. 1995, Moapa Valley, NV, Calico sandy loam soil.

Standard practice under conventional irrigation is to stop the application of water when the water front reaches a predetermined distance (based on farmer experience). However, not all irrigations reached the bottom of the field to cause runoff, whereas others may cause excessive runoff. Soil cores taken at the top, middle and bottom of the field were analyzed for water content at different times during the growing season. Water content distribution with depth is shown in Figure 2 after one such irrigation in which the conventional treatment did not lead to runoff. No differences were observed in the distribution of soil moisture at the top or middle of the field. However, at the bottom of the field, a higher moisture profile was observed unde the surge irrigation compared to the conventional irrigation.

The impact of surge irrigation on the amount of water lost beyond the rootzone was determined by analyzing the salt profile at the conclusion of the study. Figure 3 shows the soil salinity distribution with depth under both surge and conventional irrigation. An increase in soil salinity with depth suggests that the amount of water draining beyond the rootzone was declining under surge irrigation. Ratios of the salinity or chloride in the irrigation water to that in the soil solution at the 4 foot depth suggested that well over 50% of the water under conventional irrigation was in fact draining below the rootzone. Depth to the water table under both irrigation treatments oscillated around 6 feet with the lowest values occurring during the active growing period (data not shown). Although increased salinity with depth under surge irrigation reflects a move toward reducing the amount of water lost beyond the rootzone (a good thing), soil salinity must be monitored with surge irrigation to make sure no loss in yield occurs with the long-term buildup of salts (a bad thing). Based on the average soil salinity under one year of surge irrigation, a productivity loss of 2.5% would be estimated for the alfalfa (Figure 3).

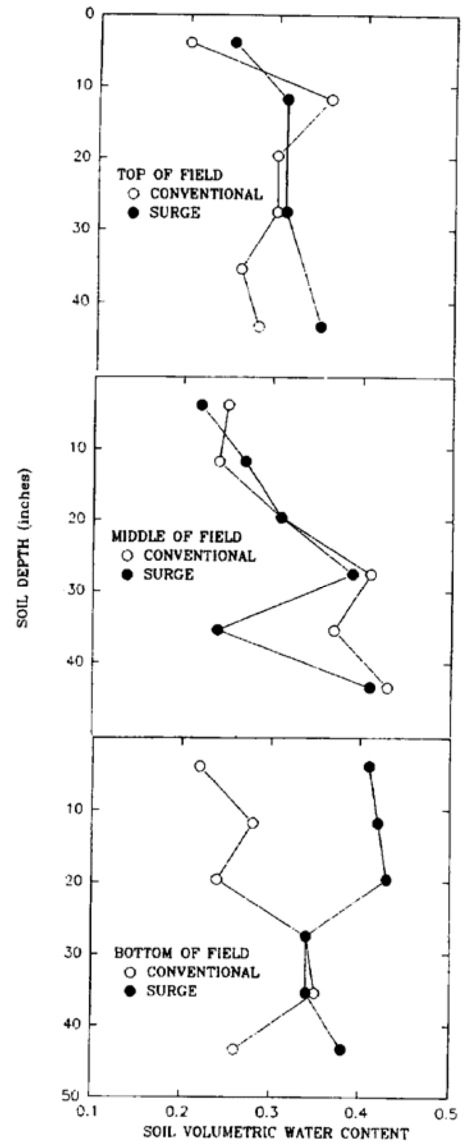

Figure 2. Soil moisture content with depth and field placement under surge and conventional irrigation. June, 1995, Moapa Valley, NV, Calico sandy loan soil.

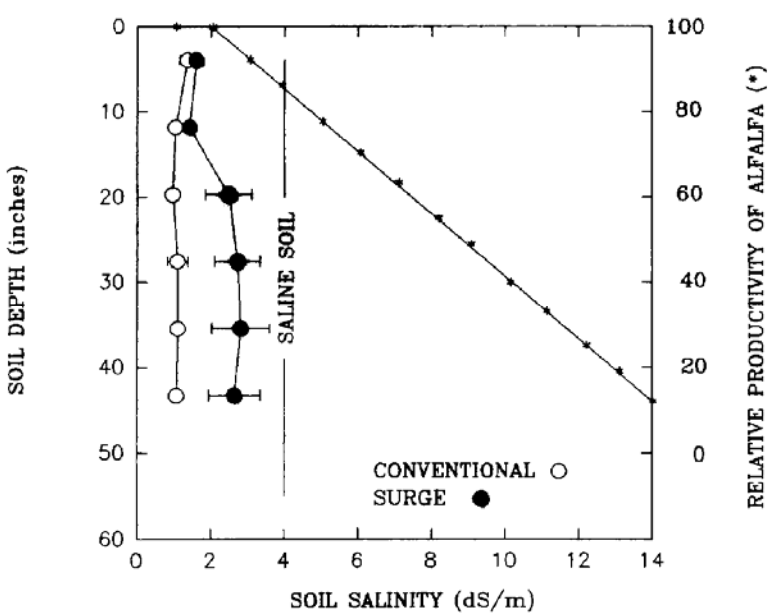

Figure 3. Average soil salinity with depth under both surge and conventional irrigation. Also indicated is the relative productivity of alfalfa as a function of soil salinity. 1995, Moapa Valley, NV, Calico sandy loam soil.

CONCLUSIONS

Surge irrigation was demonstrated to reduce the amount of water required to basin irrigate an alfalfa field while still maintaining a soil moisture profile comparable to that obtained under conventional irrigation. A 33% reduction in irrigation times associated with this technique suggests that farmers should consider surge irrigation as a management option. Although salinity reduction was not quantified, reduced leaching fractions and runoff would translate directly into salt load reduction to the Colorado River. Utilization of this irrigation technique with alfalfa does however require level basins to avoid irregular water advancement, basins with significant irrigation runs, maintenance of good border dikes, soils that do not have high clay contents, the purchase of multiple surge valves and controllers (in some situations a ported ditch system may be feasible) and the cost of water and/or energy to be high enough to justify the necessary financial investment associated with conversion to surge irrigation. Clearly, a detailed cost benefit analysis including the time required to pay back such an investment would need to be completed before such a technique is employed by the farmer.

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