SURFACE IRRIGATION MONITORING AND CELLULAR COMMUNICATION SYSTEM TO IMPLEMENT INFLOW CUTOFF STRATEGIES

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ABSTRACT

Alfalfa (*Medicago sativa* L) is a major crop in the Western United States and is the single greatest water user of all crops. It is grown on about 1 million acres in California and accounts for nearly 20% of the irrigation water use. It is usually surface irrigated using border irrigation technique. Although border irrigation is a simple and inexpensive irrigation technique, it is usually inefficient in terms of irrigation efficiency mainly due to tail discharge (Walker 1989). However, proper cutoff strategy can reduce runoff to as little as 2% from the more common 17% in the heavy clay soils (Bali et al. 2001). Under the current practice, irrigators make several trips to the field to determine when the water approaches a certain distance from the tail edge of the check (cutoff distance), typically around 200 to 300 ft from the tail (downfield) end. In spite of several trips, sometimes they may completely miss the wetting front advance to the assumed cutoff distance resulting in excessive tail drainage. A survey of local farmers and irrigators who practice surface irrigation indicated an urgent need for a simple device that can inform irrigators when the water approaches a certain distance from the tail edge. In essence, they desired a device (e.g. sensor system) to improve irrigation management, eliminate repeated field visits to monitor the wetting front, and increase the effective use of water.

To address this critical need we developed a wetting front advance system that can detect the wetting front and generate a cell phone call and alert the irrigator when the water supply needs to be cutoff so that the tail drainage can be minimized. Figure 1 shows this monitoring and alerting system being used in a surface irrigated alfalfa field. The system consists of a "Central Unit" and individual sensor poles. The irrigator places a sensor pole near the tail end of the field based on prior experience. When the surface water arrives at that location, a contact type sensor located at the bottom of the sensor pole detects the water and wirelessly communicates this information to the Central Unit. When the Central Unit receives the information it generates a cellular text message that the irrigator to turn off the inflow of water to the check. The Central Unit is capable of supporting up to 256 sensor poles all within a wireless range of approximately 0.5 miles. Arnold (2013) and Arnold et al. (2014) evaluated this system in commercial alfalfa fields in Davis, Winters and Woodland, CA during the 2011 and 2012 growing seasons. Per their results, the system worked reliably in generating a water arrival alert when the surface water arrived at the sensor pole location. These cellular text alerts assisted irrigators to eliminate the number of unproductive trips they had to otherwise make to assess the irrigation. The system

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has since been upgraded to improve functionality in commercial fields. For instance, the wireless range has been increased to about 2 miles between sensor poles and the Central Unit by working cooperatively with a Milpitas, CA based company, Cermetek Microelectronis Inc[2]. The higher range allows irrigators to monitor multiple fields using one Central Unit located at a convenient location.

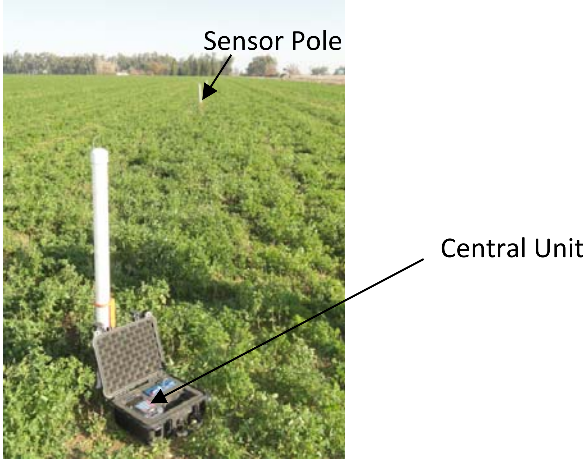

Fig. 1. The water arrival sensing and communication system

In spite of the irrigator's best judgment, Arnold (2013) found that irrigators often placed the sensor too close to the tail edge of the field. In such cases, even if the water was cutoff when the alert was received, there would still be excessive tail discharge in the range of 22 to 35% (Table 1). Perhaps, the irrigator could adjust the location of the sensor pole in subsequent irrigations, to reduce tail discharge. However, since the infiltration rate within a given check changes from irrigation to irrigation (i.e., temporal variability) a more robust approach to cutoff strategy is desirable. Towards this end, we also developed a more advanced system that can inform the irrigator exactly when to turn off the water to limit the tail discharge to a predetermined low value.

This advanced system consists of the same Central Unit and multiple sensor poles located along the centerline of a check in the direction of water flow. Two different types of sensor poles were employed in this system. The first one was the same simple contact type sensor (designated a "Type 1" sensor) described before. The second type of sensor pole had a water depth sensor in addition to the simple contact sensing elements (a "Type 2" sensor). The sensor poles with water depth sensor provided an estimation of inflow rate to the check using the very first irrigation in the check during a given season. As long as the irrigation setup and configuration are not changed, this estimated inflow can be utilized during subsequent irrigations using volume balance techniques to determine the exact cutoff location and time (Arnold, 2013 and Arnold et. al., 2014). The details of the methodology can be found in Arnold (2013) and Arnold et al. (2014). If this methodology is properly implemented, water savings in the range of 0.1125 to

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0.1325 acre-ft/acre can be realized per irrigation (Upadhyaya, 2013). For a typical 300 acre farm with five irrigations per season the water savings can be a significant 170 acre-ft to 200 acre-ft.

Figure 2. Multiple sensor poles located along the length of a check to provide an alert to the irrigator to exactly when to cutoff inflow to reduce tail discharge.

Key Words: Alfalfa, inflow cutoff, water arrival sensor, cellular communication

Table 1. Estimation of tail discharge based on farmers' field tests during the 2011 growing season.

Farm	1	2	3	4	Avg. Water Savings
Average check length, ft	1589	1268	1171	1219	-
Average field width, ft	28.2	23.4	22.8	54.4	-
Average area of the check, acre	1.03	0.68	0.67	1.52	-
Average cutoff location, ft	1450	1063	1141	953	-
Average Infiltration depth, in	4.66	3.90	7.21	3.31	-
Average depth of water prior to cutoff, in	3.14	3.07	3.21	2.13	-
Tail drainage, %	35	33	22	22	-
Tail drainage, if 0.25 in depth is allowed at the tail end, %	5.1	6.0	3.4	7.0	-
Water savings per acre per irrigation, ac-ft/ac	0.18	0.14	0.15	0.06	0.1325
Tail drainage, if 0.5 in depth is allowed at the tail end, %	9.7	11.4	6.5	13.1	-
Water savings per acre per irrigation, ac-ft/ac	0.16	0.12	0.13	0.04	0.1125

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