Adapting subsurface drip irrigation system to deficit irrigation Proceedings of Hydrology Days 2016

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Abstract. Subsurface drip irrigation (SDI) is a type of drip irrigation with buried pipe lines so that water is applied directly to the root zone and under soil surface. SDI systems have high application efficiency but need high technology for installation and are, thus, costly. SDI is relatively new to Colorado and mainly used for vegetables. As a costly system its use is still limited. However, it is compatible with automation so that timing and volume of water application can be controlled with great precision. SDI provides a good opportunity in times of water scarcity when deficit irrigation is inevitable. Drought in a river basin increases the value of water and farmers can benefit from selling part of their water to municipal and industrial water users. The remaining water is normally not enough for fully irrigating the crops so this practice is called deficit irrigation. Reduced yield due to water deficit can be predicted using crop water production functions; however, it is essential to control water application precisely so that the predicted yield is guaranteed. This paper will explore the opportunities that SDI provides for practice of deficit irrigation.

1. Subsurface Drip Irrigation Systems

ASABE (2007) defines subsurface drip irrigation (SDI) as "application of water below the soil surface through emitters, with discharge rates generally in the same range as drip irrigation." They define the common discharge for drip irrigation lower than 8 liters/hour (L/hr) for single emitters and 12 L/hr for line-source emitters. Camp (1998) in his review of articles related to SDI concludes that this irrigation system "provides a more efficient delivery system" when application is matched to crop water and nutrient requirements. However, farmers do not use drip irrigation systems (surface or subsurface) because of their efficiency. In Africa and Europe, farmers switch to drip irrigation system for its ease of use, reduction of labor costs, or because it allows irrigating on steep slopes (Kooij et al. 2013). In Colorado main reasons to convert to subsurface drip irrigation systems were reducing necessary labor and improved crop yield and quality (Bartolo 2005). Recent observations in a research field in Kersey, Colorado suggests that SDI can be well adapted to deficit irrigation.

Deficit irrigation is the deliberate under irrigation of crop (English 1990) it is an on-farm strategy to cope with water scarcity. In this practice farmers save water by accepting some yield reduction. The water saved, then can be diverted for other uses and increase net

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economic income for example by increasing land under cultivation or leasing water to off-farm demands.

2. Use of SDI Systems for Deficit Irrigation

Two main advantages of SDI systems are especially useful in practice of deficit irrigation. First is its great flexibility for system control. These systems are compatible with automation therefore timing and volume of water application parameters can be precisely controlled. Water can be applied in frequent small amounts resulting in high water application and crop uniformity. Thus, SDI can allow greater economic return when deficit irrigation is necessitated by institutional and hydrological constraints. Lamm et al (2012) suggest SDI as a tool for stabilizing yield when applying deficit irrigation.

Moreover, SDI has the opportunity of increasing yield because water is applied to the soil in shorter intervals but in small amount (Bartolo 2005). Using SDI the soil surface wetting is minimized, resulting in lower weed competition. Also periods of anaerobic conditions in the root zone is reduced therefore disease control is improved due to improved root zone. Camp’s (1998) review of several published work on SDI concludes that for over 30 crops (including grains, fodder, fruit and vegetable crops), yield for SDI was greater than or equal to that of other irrigation methods. Interestingly, new research shows that better yields are obtained with SDI under water stress. For example Colaizzi et al (2003) tested SDI and sprinkler systems on grain sorghum and found that grain sorghum produces more yield under deficit with SDI and sprinkler system gives higher yield when crop is not under water stress, confirmed by an earlier research by Schneider et al. (2001). However, the reason for this trend has not been independently researched.

Application efficiency for SDI systems can be as high as 95% (with suitable system design and good water management practices). Application of water in the soil root zone minimized water losses from surface of the soil (surface runoff and evaporation from soil surface). Low application rates and short irrigation durations can also, potentially, prevent deep percolation from the root zone, both resulting in lower system losses and higher irrigation efficiencies.

3. Subsurface Drip Irrigation in Colorado

State of Colorado is not one of the major users of SDI in the United States. The main reason is the cost of SDI. In these systems the pipelines are buried which adds to the installation cost, makes maintenance more difficult, and requires GPS technology for dripline installation in order to know the location of driplines. Another challenge that SDI users may face is germination problems. If the upward movement of water is limited, seed germination will be decreased and drastically reduce the yield. This problem, however, can be avoided by proper design of dripline burial depth and building up the soil profile’s water content by scheduling few irrigation rounds immediately after sowing. Also problem of rodents and therefore systems losses due to leakage can be sever.

Nevertheless, subsurface drip irrigation has been used for alfalfa, watermelon, cantaloupe, onion and sorghum in the State. Moreover, tomato, bell pepper, sunflower, soybean and corn have been planted under SDI in Colorado’s research fields (personal observations). The main reasons for the State’s farmers and researchers to use SDI were:

- SDI is less labor intensive compared to surface drip system as there is no need to role the driplines after growing season and lay them back in the farm for irrigation season (personal communication with Dr. Kendall DeJonge, USDA-ARS)
- Improved yield and quality (Bartolo 2005)
- [On-farm] water savings (Bartolo 2005)
- Flexibility of irrigation control and precision of irrigation flow measurement for research purposes.

4. Subsurface Irrigation Efficiency Project

Subsurface Irrigation Efficiency Project (SIEP) is a research project sponsored by Platte River Water Development Authority and conducted by Colorado State University's Civil and Environmental Engineering Department. The sponsor has dedicated a tract of land in Weld County for experimenting deficit irrigation. The research goal is to generate knowledge on methods of conserving agricultural water and transfer it to municipal and industrial users in Colorado.

The experimental field is divided into 19 zones of 3.5 to 5 acres (Figure 1). Each zone can be irrigated individually, that is applied water is controlled at the head of the zone by a valve and measured by a flow meter. Zone size is larger than conventional research plots and closer to farming plot size in the area (normally farmers irrigate every 10 acres under one valve). The field was equipped with subsurface drip irrigation system from Netafim in spring 2015. Water application is controlled by a programmable controller according to calculated water requirement on a daily basis.

In 15 of the zones the distance between the driplines is 40 inches. In zones 8, 9, 17, and 18 driplines are 30 inches apart but it is possible to turn on every other dripline so that the spacing increases to 60 inches (These zones are labeled A/B in Figure 1). System characteristics are:

Total area: 82.08 acres
Flow rate at pump: 450 GP
Type of tape: Netafim Typoon 875 13MIL
System running pressure: 20 to 22 psi
Lateral spacing: 40" and 30"
Distance between each two drippers on a tape: 24"
Number of zones running concurrently: 4

A weather station has been installed in the field (coordinates: 40.3768º, -104.532º). It is linked to CoAgMet, Colorado State University's agricultural meteorological network and has been recording data since January 1, 2015. The station's name is Kersey 2 (ID name: KSY02) and is specially equipped for ET calculation. The station is installed on a land with natural vegetation and is close to the irrigated fields. Readings of this station are available online at coagmet.com.

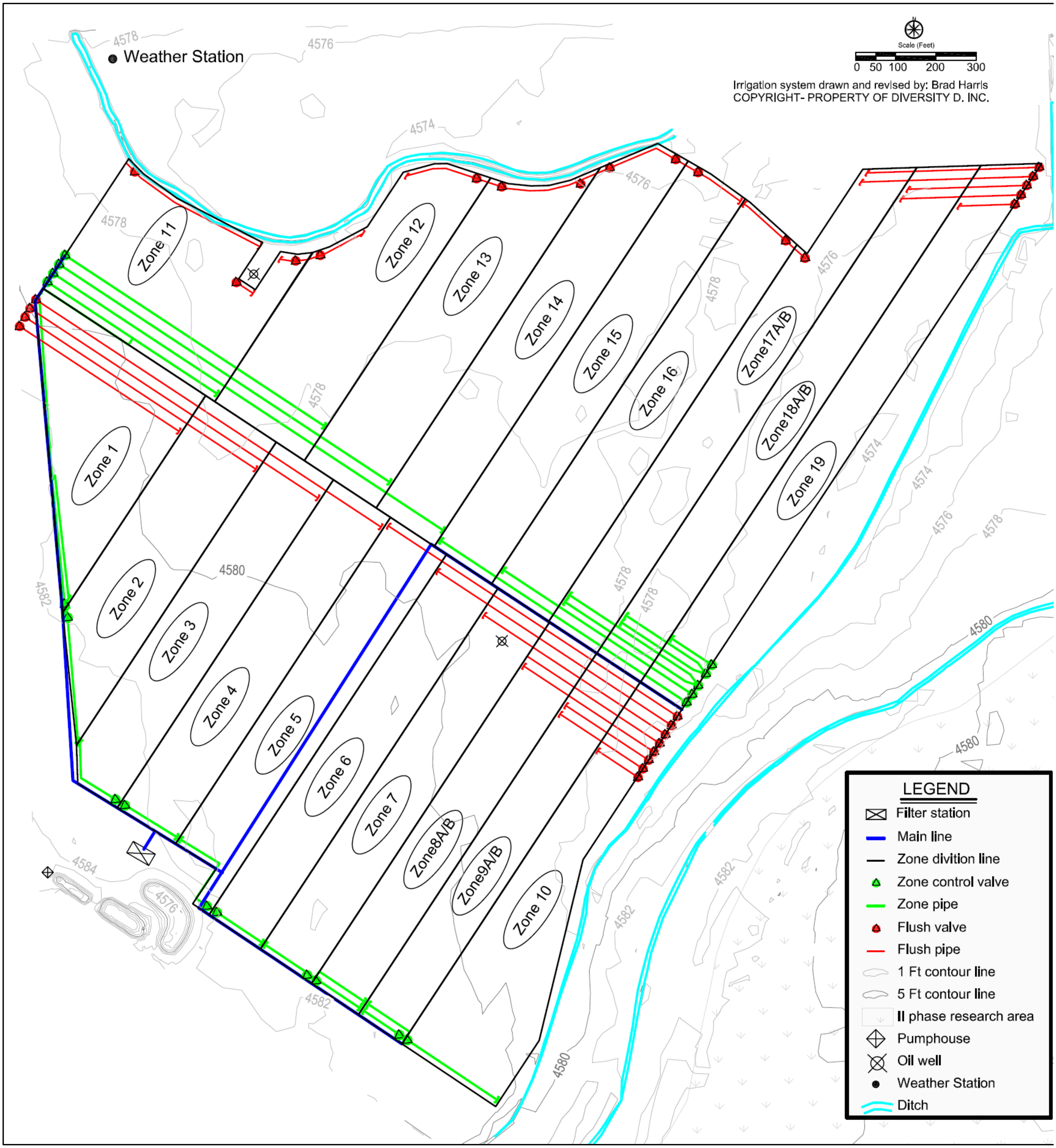

Figure 1. Layout of the experimental field.

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