How Efficient is Landscape Irrigation?

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Abstract. *The terms efficiency and uniformity are often incorrectly used interchangeably in landscape irrigation. Efficiency consists of hardware associated issues and management. Hardware includes design, installation and maintenance; management is essentially irrigation scheduling, the right amount applied at the right time. Irrigation efficiency tended to be less than 50% on homes and on plot based studies where "typical" time clock schedules were used. Optimizing time clock programming with a rain sensor could increase efficiency substantially. Smart controllers such as soil moisture sensor (SMS) or evapotranspiration (ET) controllers tended to result in irrigation efficiency above 70%.*

Keywords. Landscape irrigation, uniformity, efficiency.

Irrigation Efficiency and Uniformity

The terms efficiency and uniformity are often incorrectly used interchangeably in landscape irrigation. Irrigation system efficiency can have multiple definitions focusing on crop yield for a given amount of water supplied to the amount of water that is delivered to the crop root zone as a fraction of the amount of water pumped (Burt et al., 1997). In landscape irrigation, efficiency can be defined as the gross irrigation requirement relative to the gross irrigation delivered or pumped. The gross irrigation requirement is the net irrigation requirement multiplied by an efficiency factor to account for "reasonable" and allowable irrigation inefficiencies or other beneficial uses of water not associated with meeting plant growth needs.

Irrigation system uniformity is defined as a measure of difference in water applied to a target area relative to the amount of water intended for the target area. The majority of landscaped areas are irrigated with sprinkler irrigation, thus uniformity is a measure of variation in water applied across the target area.

Efficiency and Uniformity Data in the Literature

A few studies have been published documenting irrigation uniformity. Baum et al. (2005) documented low quarter distribution uniformity (DU_{lq}) on homes in Florida as 0.45 compared to a maximum potential uniformity of 0.55 for rotary sprinklers and 0.49 for spray heads. Although DU_{lq} is a common measure used in industry to characterize irrigation system performance, it is not analogous to irrigation system efficiency (Burt et al., 1997) and a wide range of DU_{lq} values can give relatively uniform soil moisture conditions which are conducive to good landscape quality (Dukes et al., 2006). Furthermore, while DU_{lq} may be an indicator of sprinkler irrigation performance, it does not account for irrigation system management. For example, the most uniform system achievable may be designed and installed; yet mismanagement may lead to inefficient use of water.

In this work, data on irrigation and gross irrigation requirements were assembled for a variety of plot studies, which had a wide range of irrigation application ranging from excessive irrigation to non-irrigated plots. Studies were primarily aimed at evaluating smart irrigation controllers such as soil moisture sensor (SMS) based or evapotranspiration (ET) based controllers. These controllers are intended to optimize irrigation management (i.e. scheduling), which should optimize irrigation efficiency. All of these studies included comparison irrigation treatments based on a standard time and calendar schedule. The irrigation systems were designed and installed with uniformity typical of field installations similar to those documented by Baum et al. (2005). In addition, several studies with cooperating homes were used to assess irrigation efficiency under "real-world" conditions.

Irrigation efficiency was defined based on the Smart Water Application Technologies (SWAT) protocol (IA, 2008) using a calculation of over-irrigation, scheduling efficiency, and a calculation of under-irrigation, irrigation adequacy. Scheduling efficiency is gross irrigation requirement divided by the gross irrigation applied with a provision that any number greater than 100% is fixed at 100%. Irrigation adequacy is the gross irrigation requirement minus any deficit divided by the gross irrigation requirement. Thus, if there is no soil water deficit, adequacy would be 100%.

Scheduling efficiency on actual homes tended to be around 50% or lower where landscape quality was maintained at or above acceptable levels (Fig. 1). Adding devices such as a rain sensor or SMS controller tended to increase scheduling efficiency while maintaining irrigation adequacy above a level required for good landscape quality (Fig. 2). In plot studies, generally irrigation adequacy above

70% guaranteed good turfgrass quality; however, turfgrass quality could be maintained at an acceptable visual appearance down to adequacy levels of 60% in some cases.

Conclusion

A high scheduling efficiency and irrigation adequacy in most cases was a result of an advanced irrigation scheduling technology such as SMS or ET controllers. Careful programming of a time clock irrigation schedule could also result in both high scheduling efficiency and irrigation adequacy simultaneously. In particular, schedules that apply smaller amounts of water at an irrigation event tend to promote high scheduling efficiency while maintaining irrigation adequacy. This type of irrigation scheduling needs to be evaluated with respect to turf and landscape plant health. Finally, work is needed to evaluate the concept of irrigation adequacy in terms of maintaining plant health.

References

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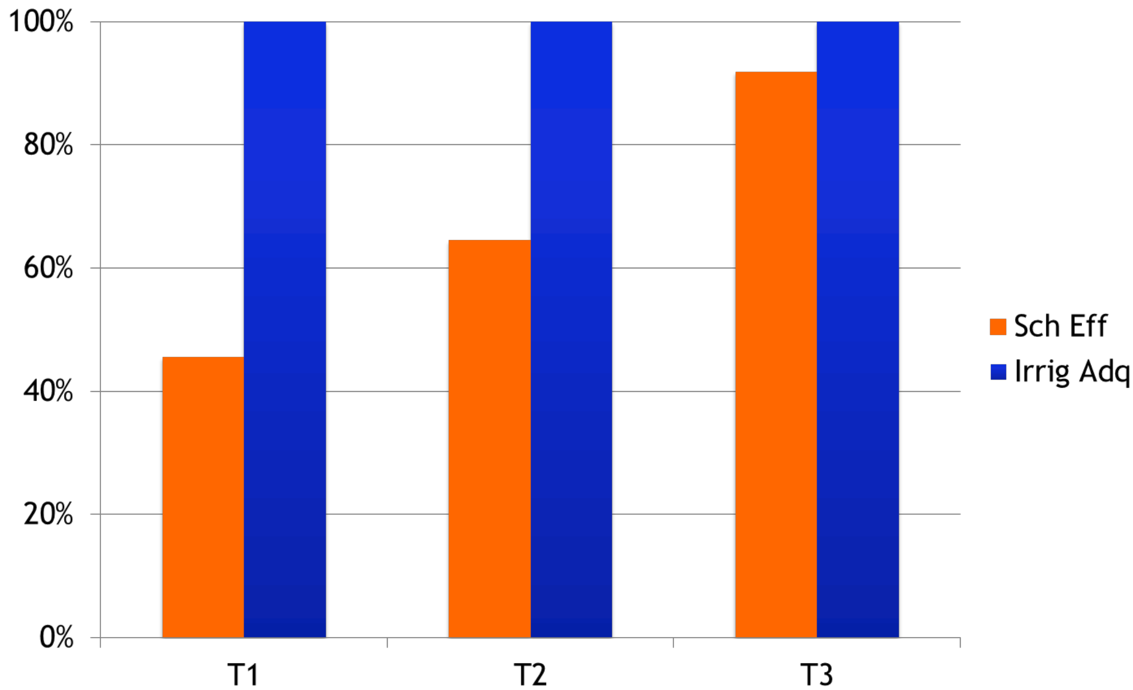

Figure 1. Irrigation scheduling efficiency and adequacy (IA, 2008) from a study by Haley et al. (2007) where T1 was homeowner scheduled irrigation, T2 was scheduled based on UF-IFAS recommendations (Dukes and Haman, 2002), and T3 was scheduled as T2 but included substantially less sprinkler irrigated area than T2. Turf quality on all homes was adequate and not significantly different across treatments.

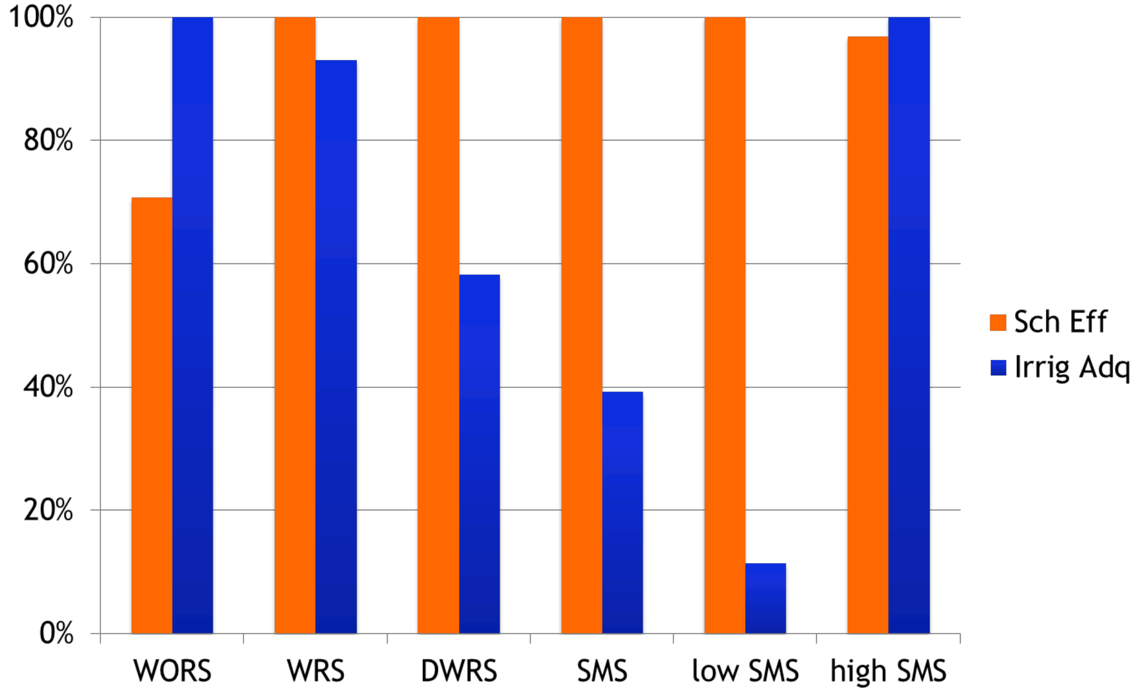

Figure 2. Irrigation scheduling efficiency and adequacy (IA, 2008) from a study by Cardenas-Lailhacar et al. (2008) where treatments were as follows: WORS, UF-IFAS recommended schedule (Dukes and Haman, 2002) without a rain sensor; WRS, UF-IFAS schedule with a rain sensor; DWRS, reduced UF-IFAS schedule; SMS, overall average soil moisture sensor treatment (4 brands and 3 day of the week frequencies); low SMS, SMS treatments with low irrigation; high SMS, SMS treatments with relatively high irrigation.