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CO-HORT

INSIDE THIS ISSUE

Synthetic Turf Gaining Favor?

Synthetic turfgrass is gaining popularity with some property owners in the water-parched West. Manufacturers of synthetic lawn products have made impressive improvements in its look and feel by blending two yarns to vary the width and height of grass of the new products. Optimum appearance is eight to ten years. Although synthetic turf is a little cooler than the sidewalk, it cannot compete with the natural cooling effect of a real lawn. Synthetic turf costs more, too. An internet search revealed the average cost of a synthetic turf installation averages $5 to $8 a square foot, compared with $2 to $3 a square foot for the installation of natural sod with a sprinkler system. Synthetic manufacturers counter that maintenance is far easier with their product, and no fertilizers, herbicides and lawn mowers are ever needed.

Some California municipalities are reportedly supporting installation of synthetic turf. The communities of Laguna Hills and Laguna Niguel intend to spend $272,300 subsidizing synthetic turf installation. Anaheim Public Utilities and the Metropolitan Water District of Southern California may offer rebates, depending on the results of a study looking at water savings and customer satisfaction. Similarly, in the Coachella Valley, Cathedral City has a pilot program that gives financial assistance to residents that replace their lawns with low-water requiring landscapes. (Sources: Irrigation Association E-Times Newsletter, October 2004; California Landscape Contractors Association Cutting Edge Newsletter, November 2004.)

Western Water Situation

Western Drought Worst in 500 Years?

U.S. Geiological Survey scientists say "Yes" the current Western drought is the worst in more than 500 years - exceeding even the Dust Bowl of the 1930's. Has the cool wet summer in parts of the Rocky Mountain West eased the situation? According to the USGS, the Western drought is now in its tenth year. Water supplies are low throughout the entire Colorado River Basin, including Las Vegas, Phoenix and Southern California. Although record keeping on Colorado River flows did not begin until 1895, scientists have used tree-ring re construction to indicate water flows in the past. They determined the lowest five-year average of water flow in the Colorado River was 8.84 million acre-feet between 1590 and 1594. From 1999 through 2003, water flow has only been 7.11 million acre-feet. (Source: American Water Works Association (AWWA), 2004, Wiserwatch Newsletter, Septemberber 2004, Waterwiser website http://www.awwa.org/waterwiser/watch/index.cfm?ArticleID=354#Western).

Lake Powell Half Empty

Here's some startling news---Lake Powell is now half empty. For years, Lake Powell has served as the "ace in the hole" for water deliveries throughout the Southwest. If Lake Powell dries up, Colorado and the other upper basin states would be required to turn off enormous trans-mountain pipes that supply the Colorado River water large numbers of residents. The Colorado River Compact of 1922 requires the states of Colorado, Utah and Wyoming to let an average of 7.5 million acre-feet of water per year to flow past Lake Powell for use by Arizona, California and Nevada. (Source: The Irrigation Association Newsletter).

Background and Evaluation of Weather-sensing Landscape Irrigation Controlers

By
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Advances in irrigation control technology provide numerous tools to landscape managers, homeowners, and water agencies for conserving water in urban landscapes. Irrigation controllers that set and adjust water application in response to changes in the weather are now available for residential and commercial use. Many of these devices utilize reference evapotranspiration (ET_o) data to calculate landscape water budgets and determine irrigation schedules. Historical and real-time ET_o data are widely available in California, and while any automatic irrigation controller can be set to apply ET_o -based schedules, the calculations and programming involved are laborious and too complicated for many people to implement. An alternative method is to install an irrigation controller that automatically adjusts watering schedules based on local weather data, or other environmental parameter correlated with ET_o and plant water demand.

In 2003, we conducted an evaluation of selected weather-sensing irrigation controllers at the University of California Riverside Turfgrass and Ornamentals Research Facility. The study was designed to determine the climatic data the controllers use, how easy they are to setup and operate, and how closely their irrigation regimes match landscape irrigation needs established by previous field research. The following summarizes the background, methods and results of the study along with our conclusions.

Background

There are at least 12 irrigation control products that autmatically schedule irrigation based on local weather or other environmental parameters. These devices are commonly termed "weather-sensing", "ET", or "weather-based" irrigation controllers, and the technology is collectively referred to by the irrigation industry as Smart Water Application Technology, or *SWAT.* The devices replace a traditional controller, or work in coordination with a traditional controller, and have proprietary hardware and/or software that automatically receive(s) or access(es) real-time or historical ET_o information or other type of environmental data to schedule and adjust landscape irrigation according to the local weather. The technologies and user interfaces employed by SWAT devices vary in complexity from traditional controller features and layouts to Internet-based management and interface. Some rely on remote communication to a data source via a telephone line, paging signal or similar technology while others use historical ET_o data modified by on-site temperature, solar radiation, or other environmental input sensors. SWAT products vary in price from about $100 to over $3,000 depending on the number of stations controlled and other variables, and some require a set-up fee or an ongoing service fee in the range of $25/yr to $250/yr.

Weather-sensing controllers are intended to efficiently irrigate landscapes by automatically calculating and implementing irrigation schedules that apply the right amount of water at the right time. Centralized irrigation control using a computer, on-site weather station data, and sophisticated valve control has been widely adopted by golf courses and other large irrigated facilities. These systems rely on advanced technology and are closely attended to by well-trained qualified personnel. In contrast, the SWAT controllers are intended to be less technical in nature and include residential and small commercial landscapes in their target audience. For residential and commercial landscapes, the SWAT controllers eliminate hand calculation of ETo-based irrigation schedules for each irrigation station, and ideally, they can take irrigation management out of peoples' hands by automatically scheduling landscape irrigation. Their proprietary algorithms purportedly tailor the amount and timing of water applied to meet the specific real-time needs of the plants and, in some cases, address the constraints of a site such as cycling irrigation of slopes to reduce runoff. In theory, the use of these devices in residential and commercial landscapes will simplify and improve landscape irrigation scheduling, minimize runoff, and result in measurable water conservation.

Urban water agencies, landscape and turfgrass management professionals, and homeowners, are interested in adopting weather-sensing irrigation controllers, but, because of the limitations of previous studies and reports, they are unsure about the effectiveness of these devices in conserving water while meeting landscape irrigation needs.

Methods

From January through December 2003, we conducted a science-based evaluation of four weather-sensing irrigation controllers to determine the climatic data the controllers use, how easy they are to setup and operate, and how closely their irrigation regimes match landscape irrigation needs established by previous field research. The study was not intended to provide head-to-head comparisons of the irrigation regimines produced by the devices selected. The products and models included in the study were Aqua Conserve ET-6 (Aquaconserve, Riverside, CA), WeatherSet WS16 (The WeatherSet Co., Winnetka, CA), WeatherTRAK (Hydropoint Data Systems, Inc., Petaluma, CA), and Calsense ET1 with an electronic ET gauge (California Sensor Corp., Carlsbad, CA) (see Table 1).

The programming procedures followed with each controller, the weather parameter(s) they employed, and the ease of interface and setup for each product were documented and appraised. Stations on each controller were set up and programmed with the minimum information needed for them to automatically schedule irrigations to the following hypothetical landscape plantings:

- Cool-season turfgrass (tall fescue) at optimum quality *(Treatment 1)*
- Trees/shrubs *(Treatment 2)*.
- Annual flowers, or about 100% ET_o *(Treatment 3)*.

Two additional stations were set up on the Weather TRAK product during the winter and summer of 2003, respectively, using the unit's following pre-set programs:

- Mixed high water use plants *(Treatment 4)*.
- Mixed low water use plants *(Treatment 5)*.

Table 1. Features of weather-sensing irrigation controllers evaluated at the University of California Riverside Turfgrass and Ornamentals Research Facility, Riverside, CA.

Feature	Aqua Conserve ET6	Calsense ET1 + ET Gauge	WeatherSet WS16	WeatherTRAK
Weather input(s) used to automatically adjust irrigation	Historical ETo modulated daily with real-time on-site temperature sensor; no automated rainfall adjustment; rain sensor can be added.	Real-time ETo from on-site electronic atmometer; historical ETo backup; soil moisture sensor is optional.	Historical ETo adjusted with on-site solar radiation ("Sunfall") sensor; rainfall sensed with MiniClik sensor.	Local real-time ETo and rainfall data sent to controller via satellite daily; can add any on/off rain sensor.
Required initial user inputs	Water days, program assignment, program start times, maximum run time for each station in July, user lockout settings.	Water days, program assignment, program start times, precip. rate for ea. station, type of sensor input, password, maximum number of stations.	Maximum daily runtime for each valve, type of plant material, start time, current time and day, no-water days.	ET zone, zip code, max ET for zone, level of automation desired, sta. start times, no-water day, type of sprinkler/emitter, plant type.
Optional user inputs	None	None	None (type of sprinkler can be input only on newer models)	Soil texture, amount of sun/shade, precipitation rate, distribution uniformity
Ease of Interface & Setup	Both easy.	Both complex.	Both easy. (display is intimidating)	Easy interface. Complex setup.
Scheduling parameters that are automatically adjusted	Run time and water days; "Accumulation" feature prevents short run-times in cool weather.	Run time, cycle repeats	Run time, then water days	Run time, water days, cycle repeats.
How often are programs adjusted	Twice/mo. based on historical ETo with daily adjustment from temperature sensor.	At each irrigation event.	Daily	Daily
Number of available programs	3	5 general and 2 drip programs.	3 pre-set programs (flowers, lawn, groundcover/shrub); water days are selected automatically. (newer model offers Low Water Use plant setting)	Each station's program and schedule are calculated by the controller from a series of user-supplied inputs for plant type, slope, microclimate, etc.
Start times per program	4	Unlimited	4	32 per station
Automatically adjusts cycles for slopes from user input?	No. Max. run time input by user must consider slope.	No. User must account for cycling on slope in initial set up.	Yes, if maximum daily runtime = 20 min. (newer models feature multiple cycle/soak options)	Yes
Programs interruptible with automatic restart?	No	Yes	No	No
No. of stations available	6 - 64	12 - 40	8 – 48	12 – 40
No. of valves that can operate on one station	2 stations plus 1 pump.	Up to 8 valves /station; can simultaneously run station from regular and drip programs.	3	1 to 2

continued

Table 1. continued

Feature	Aqua Conserve ET6	Calsense ET1 + ET Gauge	WeatherSet WS16	WeatherTRAK
External communications	No external.	Radio, modem, linkable, RS232 port.	No external.	Microwave signal from AirNet satellite.
Memory	Nonvolatile; 9v. battery retains time and date.	Nonvolatile	Nonvolatile	Nonvolatile
Security?	Yes	Yes (password)	No	Yes
Runtime clock accurate?	Yes (may be 20 to 30 sec. delay until valve actually opens or shuts).	Yes (may be 20 to 30 sec. delay until valve actually opens or shuts).	Yes (may be 20 to 30 sec. delay until valve actually opens or shuts).	Yes (may be 20 to 30 sec. delay until valve actually opens or shuts).
Misc. features	Rain switch; lock out feature to prevent unauthorized modification of program; replacement panels which fit most common controllers; usage log for current day and previous week's run times; % water reduction feature allows reduction of run-times up to 20%.	Internal crop coefficients; English or Spanish; 7, 14, 21, or 28-day schedules; laptop interface; flow monitoring and lateral break protection; usage summary; backlit 8-row display; manual adjustment of %ETo for each station.	Rain switch, master valve, manual operation of selected stations or 2-minute test.	Rain switch, master valve; manual adjustment possible from -50% to +25% for each station.
Prices (as of 2003; see mfr. for details and current pricing)	$159 for 6 stn. to $875 for 32 stn. with locking steel cabinet.	Up to $4500	$500-600: 16 stn.; $200-300: 8&12 stn.; price includes Sunfall sensor and MiniClik rain sensor.	$175 plus $48 per year signal fee.
Manufacturer contact information	Aquaconserve 2900 Adams St., Ste. A25 Riverside, CA 92504 Ph: 909.352.3891 www.aquaconserve.com	California Sensor Corp. 2075 Corte del Nogal-Ste. P Carlsbad, CA 92003 Ph: 800.572.8608 www.calsense.com	WeatherSet Company 807 Corbin Ave. Winnetka, CA 91306 Ph: 818.993.1449 www.weatherset.com	HydroPoint Data Systems 1726 Corporate Circle Petaluma, CA 94954 Ph: 707.769.9696 www.hydropoint.com

Controller setup was within manufactures' directions, but in the Weather-TRAK device, this procedure resulted in evaluating its default settings rather than its custom settings for most of the study period in turfgrass and the entire study for the other plant materials. No manual adjustments were enacted to modify the other controllers' programs.

The SWAT devices virtually controlled an existing reference irrigation system and used its system performance data as required in their initial setup. Simultaneously, the reference irrigation system was used to apply the correct amount of water to a real-time tall fescue turfgrass planting whose water needs served as the reference standard treatment comparison for the cool-season turfgrass treatment. Reference standard treatments for trees/shrubs and annual flowers treatments were calculated using on-site, real-time ET_o data and plant factors developed from previous research.

The weekly amount of irrigation actually applied to the reference turfgrass planting was recorded as were the weekly amounts of calculated irrigation required by the other reference treatment plantings. The station runtimes of the controllers evaluated were recorded and converted to depth of applied water using the performance characteristics of the reference irrigation system the controllers virtually operated. The weekly cumulative depths of water applied by controllers were summarized into monthly totals and compared to the real-time cool-season grass referenceapplications and the calculated reference standard amounts for the other treatments.

Results and Conclusions

The results of this study show each controller evaluated adjusted its irrigation schedules through the year roughly in concert with weather and ET_o changes, but the magnitudes of their adjustments were not consistently in proportion to the changes in real-time ET_o. Unfortunately, no product was able to produce highly accurate irrigation schedules consistently for every landscape setting when compared to research-based reference comparison treatments.

Aqua Conserve was simple and easy to operate, and appropriate for homeowner use. It applied water at the correct frequency and irrigated trees/shrubs with reasonably good accuracy, but it tended to apply more water than needed to all landscape treatments, especially in the summer for cool-season turfgrass. ***Calsense ET1 with an electronic ET gauge input*** offered a very complex interface, and it was equally as complex to set up. Since the electrical connections and function of the electronic ET gauge repeatedly failed in our study, it was impossible to evaluate fairly its weather-based irrigation scheduling capabilities. We believe this failure was a result of the fact we selected an ET gauge that was not proprietary to Calsense. ***WeatherSet*** was simple and easy to use but visually intimidating. It produced very inaccurate irrigation schedules that would have damaged plants due to severe under-irrigation. ***WeatherTRAK*** was a very sophisticated controller and very flexible in addressing the specific parameters found in each landscape setting, but it requires a professional landscape manager (or equivalently trained individual) to setup the unit accurately. It provided relatively accurate irrigation schedules for cool-season grass, but over-watered the trees/shrubs treatment.

Other important findings and conclusions from the controllers studied are:

- *greater complexity and technicality of required setup information does not necessarily result in more accurate, water-conserving irrigation schedules.*
- *adoption of SWAT will not eliminate human interaction in landscape irrigation management.*
- *weather-sensing controllers will likely require professional monitoring and follow-up adjustment of their initial irrigation schedules.*
- *use of weather-sensing controllers does not assure landscape water conservation or acceptable landscape plant performance.*

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The Use of Mycorrhizal Inoculants in the Ornamental Nursery Industry

by
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Mycorrhizal colonization of the root system is known to improve plant health through increased ability to absorb water and nutrients, even though overall plant growth (dry weight) may not be affected. With the availability of commercial mycorrhizal inoculum, many woody ornamental nurseries are incorporating mycorrhizal inoculum applications into their production practices. However, the infectivity and effectivity is not known for many products currently available. In addition, common nursery production practices such as high fertility (> 100 ppm nitrogen) and frequent irrigation may reduce the infectivity and survival of mycorrhizal colonies.

Infectivity Evaluations for Ten Different Commercial Mycorrhiza Inoculum

In a recent study conducted by several UCR UCCE faculty (Corkidi et al., 2004), the infectivity and efficacy of several commercial mycorrhizal inoculums were evaluated.

Infectivity was tested utilizing bioassays with *Zea mays* (corn), the standard host plant used to test mycorrhizal inoculum viability. The planting medium consisted of redwood bark, pine sawdust, calcined clay and sand (1:2:1:1 volume) and was amended with 1 lb/yd^3 of Osmocote 18-6-12. This relatively low fertilization rate was used to prevent inhibition of mycorrhizal growth by high fertility rates. In typical ornamental nursery production systems, fertilization rates usually range from 8 to 16 lb of CRF/yd^3 as well as supplemental fertilization through irrigation water. According to labels, the composition of the inoculum that was tested varied, but most products did contain *Glomus interaradices* (Table 1). Information such as application rates and expiration dates were also listed on some product labels (Table 1). Plants were grown in a greenhouse and containers were isolated from each other so that inoculum would not spread to other treatments.

Table 1. Composition, application rate and expiration date reported in the labels of different commercial mycorrhizal inoculants.

Product	Composition	Application rates/pot	Expiration date
Earth Roots	Vesicular arbuscular mycorrhizal fungi	1 tsp	2004
MycoApply endo	*Glomus intraradices*	10 g	--
VAM80	*Glomus intraradices*	1 tsp	2004
Ascend PB	*Glomus intraradices*	1 g	2002
5.	*Glomus intraradices*	2 tbsp	2004
NTC	*Glomus intraradices*	30.5 ml	2002
7.	*Glomus and Gigaspora spp.*	¼ tsp	2004
8.	One or more species of arbuscular mycorrhizal fungi.	2.9 g	2003
9.	Endo/Ectomycorrhizal inoculum	1 tsp	--
10.	*Glomus intraradices*	1 tsp	--

After six weeks of growth, plants that were inoculated with mycorrhizal products 1, 2, 3, 4, 5 and 7 showed colonization. Plants inoculated with products 6, 8, 9 and 10 did not produce mycorrhizal colonization.

Effects of Inoculum and Media Type on Mycorrhizal Colonizations

A second study was conducted in these evaluations to determine if colonization of plant roots with mycorrhiza may also depend on the media type since previous studies have shown that physical and chemical characteristics of artificial growing media may adversely affect mycorrhizal colonization. Three different types of media were used in the experiment: (1) nursery mix - redwood bark, pine sawdust, calcined clay and sand (1:2:1:1 volume); (2) soil mix – soil:sand (1:1 volume); and (3) Sunshine Mix #5 – a peatmoss based medium. These media types differed in the amount of organic matter and in nutrient levels (Table 2).

Table 2. Nutrient concentrations of the three media used to test the infectivity and effectivity of different mycorrhizal products on *Zea mays* (corn). Additional fertilizer was added to each substrate type through the incorporation of 1 lb Osmocote 18-6-12/yd^3.

Media Type	pH	NO_3-N	NH_4-N	PO_4	K	Ca	Mg	Cu	Zn	Mn	Fe
Nursery	7.4	66	91	10	640	9520	1140	9	12	34	18
Soil	7.3	16	9	7	170	4460	476	1.4	3	7	8
Sunshine	5.2	452	65	224	1000	9800	2920	6.4	28	48	292

After seven weeks of growth, the effects of media type and mycorrhizal product on mycorrhizal colonization was evaluated on corn plant roots. The use of products 7, 8, 9, and 10 did not result in mycorrhizal colonization in any of the media types; therefore, their results are not included. For products 1 through 6, the type of inoculum had a significant effect on the percentage of mycorrhizal colonization (Table 3). However, the effects of media type on colonization were variable (Table 3). The products of Earth Roots, MycoApply endo, VAM 80 had significantly greater colonization than products of Ascend PB, Product #5 and NTC, when grown in the Nursery or Soil mixes. For plants grown in Sunshine Mix, Earth Roots in-

Table 3. The percentage of mycorrhizal colonization of *Zea mays* (corn) as affected by different commercial inoculum and media types. Colonization was quantified by counting the number of intraradical hyphae, arbuscules and vesicles on roots.

Mycorrhizal Inoculant	Nursery Mix	Soil Mix	Sunshine Mix #5
Earth Roots	^{z}A 35.1 a^y	A 35.2 a	A 50.7 a
MycoApply endo	A 21.7 b	B 9.2 a	B 13.9 ab
VAM 80	A 42.9 a	B 17.9 a	C 6.5 b
Ascend PB	B 2.8 a	C 3.6 a	B 21.5 b
Product #5	B 0.8 a	C 4.5 a	C 0.9 a
NTC	B 4.7 a	C 0.2 a	C 1.0 a

^{z}Different upper case letters within a column indicate significant differences among mycorrhizal treatments. P = 0.5.
^{y}Different lower case letters across rows indicate significant differences among different media types. P = 0.5.

oculum resulted in the greatest colonization, followed by MycoApply endo and Ascend PB. Product #5 and NTC resulted in the least amount of colonization in the Sunshine Mix (Table 3).

Effect of Media Type on Plant Growth

Within a given mycorrhizal inoculum treatment, shoot dry mass was significantly affected by media type, with plants grown in Sunshine mix producing the greatest amount of dry mass compared to the Nursery mix and the Soil mix (Table 4). This growth response occurred within all mycorrhizal products tested. This may be partially explained by the fertility status of the media, since Sunshine mix had greater levels of nitrogen, phosphorus, potassium, magnesium and iron than the other two media types (Table 1).

Effect of Mycorrhizal Inoculum Type on Plant Growth

For inoculums that caused colonization of roots, shoot dry mass was not affected by inoculum type, when grown in the Nursery mix (Table 4). In the Soil mix, shoot dry weight was significantly less for plants inoculated with Ascend PB compared to the other inoculums (Table 4). However, in Sunshine mix #5, shoot dry weight of plants inoculated with Earth Roots was lowest compared to the shoots of plants inoculated with the other mycorrhizal products (Table 4). Interestingly, the mycorrhizal products (#8, 9 and 10) that did not produce mycorrhizal colonization in any of the bioassay tests, resulted in the highest shoot dry weights (Table 4), suggesting that some type of growth promoting substance was present in the product. However, chemical properties were of products were not evaluated in this study.

Based on the overall results of this study, the infectivity and effectivity of different mycorrhizal products is variable. However, several products, when used properly, will result in colonization of plant roots. Please note that in this study, corn was used as the host plant since it is very responsive to mycorrhizal colonization. However, other plant species may not

Table 4. Shoot dry mass (g) of *Zea mays* (corn) as affected by different commercial inoculum and media types.

Mycorrhizal inoculant	Shoot dry mass (g)		
	Nursery Mix	Soil Mix	Sunshine Mix #5
1	A 0.306 a	A[z] 0.247 a[y]	C 0.589 b
2	A 0.492 a	A 0.396 a	A 1.040 b
3	A 0.426 a	A 0.308 a	A 1.039 b
4	A 0.406 b	C 0.163 a	A 0.852 c
5	A 0.309 a	A 0.277 a	A 0.787 b
6	A 0.312 a	A 0.272 a	A 0.856 b
7	A 0.500 a	A 0.413 a	A 0.850 b
8	A 0.380 a	A 0.313 a	A 0.853 b
9	B 0.733 a	B 0.630 a	B 1.397 b
10	B 0.820 b	B 0.487 a	B 1.190 c

[z]Different upper case letters within a column indicate significant differences among mycorrhizal treatments. P = 0.5.
[y]Different lower case letters across rows indicate significant differences among different media types. P = 0.5.

be as successful in mycorrhizal colonization, even though the inoculum is viable.

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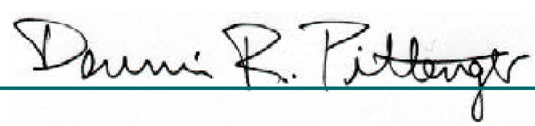

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