IRRIGATION WATER BANKING ON TALL FESCUE MAINTAINED IN THE INLAND CLIMATIC CONDITIONS OF RIVERSIDE

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JANUARY 1998 TO DECEMBER 2000

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FINAL REPORT

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TABLE OF CONTENTS

LIST OF FIGURES AND TABLES

PRACTICUM

Previous studies at the University of California South Coast Research and Extension Center (Irvine, Calif.) showed that acceptable tall fescue quality could be maintained when irrigated with 80% reference evapotranspiration (ET_o). Research at Riverside, however, has shown that tall fescue requires more than 80% ET_o in inland valleys to maintain acceptable visual quality (ratings ≥6.0), especially during hot summer months. In reality, water requirements are even higher in most commercial landscapes due to poor irrigation uniformity and reduced irrigation efficiency (i.e., more water is required to compensate for dry areas caused by poor irrigation system performance, runoff, etc.). The current study "Irrigation Water Banking on Tall Fescue Maintained in the Inland Climatic Conditions of Riverside" has shown that the effects of reduced irrigation and system performance can be mitigated by proportioning an 80% ET_o annual irrigation allotment differently. Specifically, tall fescue performance can be improved when irrigation is reduced during cooler seasons of the year, and proportionally increased during the warm season (April through September).

These treatments were termed "water banking" treatments and consisted of applying 40, 92, 91, and 70% historical ET_o, or 40, 85, 97, and 70% historical ET_o during the January to March, April to June, July to September, and October to December quarters of the year, respectively. The water banking treatments were compared to watering with 80% historical ET_o plus rain (hereafter 80% historical ET_o) with quarterly controller adjustment, or 80% real-time ET_o plus rain (hereafter 80% $ET_{o(real\text{-}time)}$) from an adjacent CIMIS weather station with weekly controller adjustment. The study revealed that the water banking treatments performed as well as or better than the 80% $ET_{o(real\text{-}time)}$ treatment during the 3 years of the study, especially during the critical 3-month quarter of July to September (see table below). This is significant from the standpoint of improved performance with quarterly irrigation controller programming, versus weekly programming which was employed with the 80% $ET_{o(real\text{-}time)}$ treatment. Improved tall fescue visual performance was supported by increased soil water content in plots irrigated with the water banking treatments. These results may be significant for local water districts seeking to better correlate water allotments with seasonal plant water requirements.

The effect of four irrigation treatment regimes on the number of rating dates during the July to September quarters in 1998, 1999, and 2000 that tall fescue visual quality and color was ≥ 5.5. The data indicate that the water banking treatments (shaded columns) produced higher ratings (more ratings ≥ 5.5) than the 80% ET_o treatments.

	Irrigation treatment			
	80, 80, 80, 80% historical ET_o	**40, 92, 91, 70% historical ET_o**	**40, 85, 97, 70% historical ET_o**	**80, 80, 80, 80% real-time ET_o**
3-yr totals (1998-2000): July to September				
No. of rating dates	**19**	**19**	**19**	**19**
No. dates where:				
Quality ≥ 5.5	**3**	**11**	**11**	**6**
Color ≥ 5.5	**7**	**13**	**12**	**7**

See Table 58 for the same information for all four 3-month quarters.

EXECUTIVE SUMMARY

A 3-year study was completed in which the performance of tall fescue was evaluated when treated with four irrigation regimes. Two irrigation regimes applied a constant amount of either 80% historical ET_o, or 80% real-time ET_o (from CIMIS). The other two irrigation regimes were termed "water banking" because there was an increased irrigation amount during the warm season to improve tall fescue performance. Cool-season irrigation was proportionally adjusted downward to make up for the addition of warm-season irrigation. Data from this 3-year study indicates that tall fescue performance can be improved, depending on how the annual 80% historical ET_o allotment of irrigation water is proportioned. The following general observations and conclusions arose from this study:

1. The annual allotment of 80% ET_o produced better visual turfgrass quality in 1998 than in 1999 and 2000. This was most likely due to below-average rainfall during the latter 2 years. However, it should be noted that an annual allotment of 80% ET_o is not sufficient water to maintain tall fescue in Riverside. Also, it should be noted that 80% ET_o is equal to approximately 100% ET_o in the industry because irrigation system distribution uniformity (DU) of the research plots may be 20% higher than the DU of typical landscape sites.

2. The water banking treatments were adjusted after 1998 because it was determined that more water could be "banked" during the January to March quarter, and more water was needed to be applied during the October to December quarter. These adjustments improved the performance of the water banking treatments in 2000.

3. During the critical July to September quarter, the water banking treatments performed as well as the 80% $ET_{o(real\text{-}time)}$ treatment in 1998 and better than this treatment in 1999 and 2000. Better visual ratings for the water banking treatments are supported by lower soil water tension and higher soil water content, particularly at the 36-inch depth. This is significant because the water banking treatments required only one irrigation run time setting for the quarter, while the 80% $ET_{o(real\text{-}time)}$ treatment required weekly controller programming. The former scenario is more consistent with industry practice.

4. The treatment of irrigating tall fescue at a constant rate of 80% historical ET_o was inferior to the water banking treatments from July to September during all 3 years. Superior performance of the water banking treatments compared to both 80% ET_o treatments is also apparent when visual turfgrass quality and color ratings dates ≥ 5.5 are added for 3 years for the July to September quarter (Table 58).

5. Considering annual performance, the worst irrigation treatment was the constant rate of 80% historical ET_o in 1998, while the 80% $ET_{o(real\text{-}time)}$ was the worst treatment in 2000.

6. Although visual ratings did not differ significantly between the two water banking treatments, soil water content at the 36-inch depth, was highest for the 40, 85, 97, 70% irrigation regime on many dates in 1999 and 2000 suggesting that this treatment may be slightly better than the 40, 92, 91, 70% treatment.

BACKGROUND

Urban landscapes, including areas planted with turfgrass, offer numerous functional, recreational, and aesthetic benefits. Several functional benefits include excellent soil erosion and dust stabilization; improved recharge and quality protection of groundwater; enhanced entrapment and biodegradation of synthetic organic compounds; heat dissipation and temperature modification; reduced noise, glare, and visual pollution problems; and lowered fire hazard via open green-turfed firebreaks. The 1997 estimate of $2,184,000,000 spent annually on turfgrass maintenance in California also is a significant benefit to the state’s economy. This estimate was based on a published figure for 1982 and corrected for inflation (multiplier = 1.54) and for population increase (multiplier = 1.34).

Although the establishment and maintenance of quality, functional turfgrass is justifiable, developing and implementing best management practices (BMPs) also is important for the responsible use and protection of natural resources. Currently, there is considerable interest in developing and implementing BMPs for addressing water conservation in urban landscapes. Although several environmental issues are important for turfgrass management, the use (conservation) of irrigation water on urban landscapes, including turfgrass, is the most general driving force in California. Current policies indicate that 80% to 100% ET_o will be the amount (measured in depth units) of irrigation water that will be allowed, without penalty, for use on landscape sites. It appears that this allotment will be based on real-time ET_o from CIMIS stations.

Research described herein was conducted on tall fescue, currently the most widely planted turfgrass species in California. Previous research on tall fescue, maintained in the southern inland valley weather conditions of Riverside, showed that an irrigation amount of not less than 85% ET_o would be required to maintain minimally acceptable visual quality during the warm season. Actually, 100% ET_o may not be enough irrigation water to maintain quality tall fescue during the warm season in Riverside on many landscape sites because the irrigation system DU of the research plots may be 20% higher than the DU of typical landscape sites. It should be noted that a substantial amount of landscape irrigation water is used by inland locations.

Irrigation protocol in this study allowed for an 80% ET_o plus rain allotment on an annual basis. Yearly allotment allowed for “water banking;” that is, an increased irrigation amount during the warm season to improve grass performance, and then proportionally adjusting the cool-season irrigation amount downward to make up for the additional irrigation during the warm season. Cool-season downward adjustment was possible because rainfall during this period supplemented irrigation. Historical ET_o was utilized to test for the warm-season benefits of water banking, but this same approach could have been applied to real time ET_o. Specific objectives for the study were as follows:

1. Test irrigating tall fescue at a defined annual amount (80% historical ET_o) with increased irrigation during the warm season to improve grass performance, and then proportionally adjusting the cool-season irrigation amount downward to make up for increased warm-season irrigation. These treatments were compared to irrigating tall fescue at a constant rate of 1) 80% historical ET_o and 2) 80% ET_o (CIMIS real-time) (see Fig. 1 and Tables 2 and 3).

2. During key times of the study, determine the influence of irrigation treatments on visual turfgrass quality, color, and drought symptoms, clipping yield, clipping water content, relative leaf water content, leaf water content, and volumetric soil water content and soil water tension. These measurements were collected on the Jaguar III subplot within each irrigation main plot (see Fig. 1).

A third objective of this study was to test the influence of annual N-fertility rate on the performance of tall fescue in conjunction with irrigation treatments. Previous research on turfgrass has shown a significant influence of annual N-fertility level on water use and drought stress tolerance. Annual N-fertility levels that are either too low or too high significantly reduce turfgrass drought stress tolerance and therefore are not efficient. It should be noted that this objective was part of a project funded by the California Department of Food and Agriculture (CDFA) Fertilizer Research and Education Program (FREP). This study was conducted on the Shortstop tall fescue plot within each irrigation main plot. (See Fig. 1 and Tables 2 and 3).

MATERIALS AND METHODS

The performance of Jaguar III turf-type tall fescue was evaluated when irrigated with four irrigation regimes. The four irrigation treatment regimes were as follows for 2 April 1998 to 31 December 1998:

A. 80, 80, 80, 80% ET_o (historical) applied during the January to March, April to June, July to September, and October to December quarters, respectively.
B. 58, 90, 90, 58% ET_o (historical) applied during the January to March, April to June, July to September, and October to December quarters, respectively.
C. 58, 96, 85, 58% ET_o (historical) applied during the January to March, April to June, July to September, and October to December quarters, respectively.
D. 80, 80, 80, 80% ET_o (real-time from CIMIS) applied during the January to March, April to June, July to September, and October to December quarters, respectively.

Treatments B and C applied extra irrigation during the warm season to improve grass performance, and then proportionally adjusted the cool-season irrigation amount downward to make up for the increased warm-season irrigation. Treatments B and C where adjusted as follows for 1999 and 2000 based on results from 1998:

B. 40, 92, 91, 70% ET_o (historical) applied during the January to March, April to June, July to September, and October to December quarters, respectively.
C. 40, 85, 97, 70% ET_o (historical) applied during the January to March, April to June, July to September, and October to December quarters, respectively.

Two cultivars of tall fescue, Jaguar III (standard turf-type) and Shortstop (dwarf-type) were seeded at a rate of 7 lb/1000 ft^2 on a Hanford fine sandy loam (coarse-loamy, mixed, Thermic Haplic Durixeralf) at the turfgrass research facility at the University of California, Riverside. The study was seeded in Jan., 1994 with each cultivar randomly assigned to one-half of each irrigation main plot.

A special field plot arrangement was necessary to allow individual irrigation control of each of the 12 main plots. Irrigation main plots measured 20 × 20 ft. Each main plot was irrigated with Hunter PGM® rotors located at the four corners of each plot. Care was taken to maximize DU of the 12 irrigation system main plots by ensuring that head alignment was vertical, and system operating pressures were within the manufacturer's recommended range. Catch-can tests were performed in the spring of each year to check performance of the 12 systems and to update precipitation rates for irrigation programming. The average DU was 0.86 and ranged from 0.83 to 0.89.

Experimental design was a randomized complete block design with 3 replications for each of four irrigation treatments. Irrigation main plots were blocked according to irrigation system DU. Data for the water banking study was collected from each 10 × 20 ft Jaguar III subplot within each irrigation main plot (see Fig. 1).

The research plots were fertilized quarterly in 1998 at a rate of 1.125 lb N/1000 ft^2 using a 30-inch Gandy drop spreader. The nitrogen source was $CaNO_3$ in March and October, and NH_4NO_3 in May and August. Fertilizer application for 1999 and 2000 differed as follows: plots were fertilized quarterly at a rate of 1.5 lb N/1000 ft^2 using Polyon® polymer-coated urea (43-0-0) during October and March applications and Polyon® polymer-coated urea (42-0-0) during May and August applications. P_2O_5 was applied as needed, according to an annual soil test in December. K_2O was applied in April, May, June, November and December at the rate of 1.2 lb K_2O/1000 ft^2 per application (for a total of 6.0 lb K_2O applied during the year). Plots were mowed each Friday using a 21-inch walk-behind rotary mower set at a 1.5-inch mowing height with clippings collected. Refer to Table 1 for other general maintenance practices.

Plots were irrigated with two irrigation events per week according to irrigation treatment protocol. Quarterly historical ET_o quantities were calculated from monthly historical ET_o tables (Tables 2 and 3). This quantity was multiplied by the irrigation treatment percentage for the quarter to yield irrigation treatment quantity (Tables 2 and 3). Irrigation treatment quantity was then divided equally among the number of Wednesday and Saturday irrigation events for the quarter and multiplied by respective main plot precipitation rates to yield individual irrigation event run times. These times were programmed into the Rainbird ISC controller, and divided into multiple cycles to maximize infiltration. Table 1 details the steps used to calculate quarterly irrigation programs. Rainfall was not subtracted from the quarterly irrigation treatment quantity, but individual rainfall events totaling 0.5 inch resulted in the cancellation of an irrigation event. Careful records of rainfall amounts and irrigation events were maintained.

Irrigation treatment D [80% $ET_{o(real\text{-}time)}$] was programmed into the controller every Tuesday based on the previous 7-d ET_o from a CIMIS station located 169 ft from the research plot. Accumulative 7-d ET_o was multiplied by 0.8, multiplied by plot precipitation rate (min/mm), then divided by 2 irrigation events per week to determine run time per day. Run time per day was divided by the number of irrigation cycles per day (four) to determine run time per cycle – the number programmed into the controller.

Turfgrass visual ratings, including visual turfgrass quality and color, percent rolled and/or wilted leaves, and percent brown leaves, were taken on the plots according to the protocol listed in Table 1. The latter two ratings, or so-called “drought ratings,” reflected the plant response to reduced irrigation. Other plant measurements were taken to determine the effect of irrigation treatments on plant growth and water status. The first of these was clipping yields (see Table 1: “Other Plant Measurements”) which were always taken 4 weeks following fertilizer applications. Clippings were collected from an area representing 17.5% of the subplot surface area using a 21-inch Toro commercial rotary mower equipped with a yield box attachment. Clippings were processed as detailed in Table 1. Clipping water content [fresh weight - dry weight)/dry weight] was measured concurrently with clipping yields. Upon removal from the yield box attachment, clippings were brushed into a tared brown paper bag and immediately weighed. Clippings were then dried and dry weights recorded.

Relative leaf water content (RLWC) and leaf water content also were measured periodically to determine the water status of the tall fescue leaves under different irrigation regimes. Table 1 (“Other plant measurements”) details the procedure used to calculate RLWC and leaf water content.

Two procedures were employed to measure soil water tension and soil water content (see Table 1: “Soil water tension and content). Soil water tension was measured at 6- and 12-inch depths in two locations or subsamples within each Jaguar III subplot using Watermark granular matrix sensors connected to remote readers (Irrometer Co., Riverside, Calif.) at the edge of the research plot. The sensors were read twice weekly, before and after irrigation, using a Watermark Soil Moisture Meter. These readings indicated how dry the soil was by measuring soil water tension. This was a measure of the force (or “suction”) the plant roots must exert (units = centibars or KPa) to overcome soil matric forces holding water in the soil.

Volumetric soil water content was measured with neutron scattering (Boart Longyear CPN 503 DR Hydroprobe) to a 4-ft depth (9-, 12-, 24-, 36-, and 48-inch increments) in two locations or subsamples within each Jaguar III subplot. Readings were taken monthly. The calibration curve relating count ratio to volumetric soil water content was derived from 39 soil samples extracted from the research plot and two neighboring research plots. The equation relating neutron counts to soil water content was:

volumetric soil water content (cm^3 H_2O/cm^3 soil) = (36.379*count ratio) - 12.927

where R-square = 0.90 and count ratio is the ratio of recorded neutron counts to a standard count.

Irrigation treatment effects on visual turfgrass quality and color, percent leaves rolled and/or wilted, percent brown leaves, clipping yield, clipping water content, RLWC, leaf water content, and soil water content and tension were tested by a randomized complete block analysis of variance (ANOVA) according to the general linear models procedure of the Statistical Analysis System (SAS Institute Inc., Cary, N.C.). A repeated measures ANOVA also was performed for visual turfgrass quality and color, percent leaves rolled and/or wilted, percent brown leaves, clipping water content, RLWC, leaf water content, and soil water content and tension with date as the repeated measures factor. Means of irrigation treatments were compared by using a Fisher's Protected LSD test.

Table 1. Materials and methods outline for the 1998 to 2000 irrigation water banking of tall fescue maintained in the inland climatic conditions of Riverside study.

Objectives:	1. Test irrigating tall fescue at a defined annual amount (80% historical ET_o) with increased irrigation during the warm season to improve grass performance, and then proportionally adjusting the cool-season irrigation amount downward to make up for the addition of warm-season irrigation. These treatments were compared to irrigating tall fescue at a constant rate of 1) 80% historical ET_o and 2) 80% $ET_{o(real\text{-}time)}$ (see Fig. 1 and Tables 2 and 3). 2. During key times of the study, determine the influence of irrigation treatments on visual turfgrass quality and color, drought symptoms, RLWC, leaf water content, clipping yield, clipping water content, and volumetric soil water content and soil water tension. These measurements were collected on the Jaguar III subplot within each irrigation main plot (see Figure 1). 3. In conjunction with irrigation treatments, test the influence of the annual N-fertility rate on the performance of tall fescue. It should be noted that this objective was part of a project funded by the CDFA-FREP. It was conducted on the Shortstop tall fescue subplot within each irrigation main plot. (see Fig. 1 and Tables 2 and 3).
Species:	Jaguar III turf-type tall fescue (*Festuca arundinacea* Schreb.)
Location and root zone:	Block 12 E, plot number 2, UCR Turfgrass Field Research Facility. Root zone is a well-drained native alluvial soil (Hanford fine sandy loam: coarse-loamy, mixed, Thermic Haplic Durixeralf)
Experimental design:	Randomized complete block design with 3 replications for each of four irrigation treatments. Irrigation main plots were 20 × 20 ft and were blocked according to irrigation system DU. MWD data was collected from each 10 × 20 ft Jaguar III subplot within each irrigation main plot (see Fig. 1).

Fertilization:

1998: Nitrogen was applied quarterly at a rate of 1.125 lb N/1000 ft^2 using a calibrated 30-inch Gandy drop spreader. Nitrogen source was $CaNO_3$ in March and October, and NH_4NO_3 in May and August.

1999-2000: Nitrogen was applied quarterly at a rate of 1.5 lb N/1000 ft^2 using a calibrated 30-inch Gandy drop spreader. Nitrogen source was Polyon® polymer-coated urea (43-0-0) for March and October applications and Polyon® polymer-coated urea (42-0-0) in May and August.

P_2O_5 was applied as needed, according to an annual soil test in December. K_2O was applied in April, May, June, November and December at the rate of 1.2 lb K_2O/1000 ft^2 per application (for a total of 6.0 lb K_2O applied during the year). Dec. 97 soil test: 1.42% OM, 11% clay, 47% sand, and 42 % silt; pH = 7.2; P-Olsen = 44.4 ppm; exchangeable K, Ca, Mg, and Na = 0.276, 8.6, 1.7, 0.3 meq/100g, respectively. CEC = 12.5 meq/100 g; SAR = 1; ESP (%) < 1; soluble Ca, Na, Mg = 8.0, 3.0, 2.2 meq/L, respectively. DTPA extractable Fe = 23 ppm.

Mowing:

Each Friday, using a walk-behind, rotary mower set at a 1.5-inch mowing height. Clippings were collected. Note that the Jaguar III and Shortstop tall fescue subplots were mowed simultaneously at the same height. Blade sharpness was checked every 2 weeks and sharpened as needed.

General maintenance:

1. Irrigation systems of each irrigation main plot were checked every 2 weeks for proper operation. (see section below).
2. Weeds were controlled as needed with manual cultivation and herbicides.
3. Vegetative growth in proximity to neutron probe access tubes was trimmed as needed for easy access.

Irrigation: Two irrigation events/week, according to irrigation treatment protocol (Tables 2 and 3) (see section below). Irrigation events were on Wednesday and Saturday morning, before sunrise. Irrigation water was from the Riverside potable water supply and has an analysis as follows: pH = 8.4, EC = 0.60 mmhos/cm, Ca = 3.9 meq/L, Mg = 1.1 meq/L, Na = 1.5 meq/L, SAR < 1, Cl = 8.6 meq/L, B = 0.1 ppm, HCO_3 = 3.4 meq/L, CO_3 < 0.1 meq/L, SO_4-S = 24 ppm. Main plots were irrigated by four Hunter PGM® rotors equipped with 1.0 gpm nozzles and located at the four corners of each plot.

Irrigation system checks: Vertical of all heads was checked with a level and adjusted once every 2 weeks. Catch-can tests were performed in the spring to determine system precipitation rates and the DU of each irrigation main plot. Maximum DUs were obtained by ensuring system operating pressures (measured at solenoid valve) were close to manufacturer's recommendation (40 psi), and by maintaining head alignment and arc adjustment. Most recent precipitation rates of each irrigation main plot were used in calculating irrigation run times.

Proper clock (Rainbird ISC24+) operation was monitored by 24 VAC hour meters (IVO model B148) wired in parallel with solenoid valves.

Irrigation programming and rainfall: Quarterly historical ET_o quantities were calculated from monthly historical ET_o tables. This quantity was multiplied by the irrigation treatment percentage for the quarter to yield irrigation treatment quantity (Tables 2 and 3). Irrigation treatment quantity was then divided equally among the number of Wednesday and Saturday irrigation events for the quarter and multiplied by respective main plot precipitation rate (min/mm) to yield individual irrigation event run times. These times were programmed into the Rainbird ISC controller, and divided into multiple cycles. Each cycle was less than 15 minutes for maximum infiltration:

1. Historical 3-month ET_o x quarterly % = *irrigation treatment quantity.*

2. Irrigation treatment quantity ÷ number of Wed., Sat. irrigation events =

Irrigation quantity per event.

3. *Irrigation quantity per event* x plot precipitation rate (min/mm) =

   Irrigation event run time (minutes).

4. *Irrigation event run time* ÷ number of cycles = *Irrigation controller run time*

Rainfall was not subtracted from the 3-month irrigation treatment quantity, but individual rainfall events totaling 0.5 inch or more resulted in cancellation of an irrigation event. Careful records of rainfall amounts and irrigation events were maintained.

Irrigation treatment D [80% $ET_{o(real\text{-}time)}$] was programmed into the controller every Tuesday based on the previous 7-d ET_o from a CIMIS station located 169 ft from the research plot. Accumulative 7-d ET_o was multiplied by 0.8, multiplied by plot precipitation rate (min/mm), then divided by two irrigation events per week to determine run time per day. Run time per day was divided by the number of irrigation cycles per day (four) to determine run time per cycle – the number programmed into the controller. Hour meter readings were recorded and compared with the previous weeks' readings to check for proper clock operation.

Measurements:

Turfgrass visual ratings

Quality and color ratings

- Visual turfgrass quality measured on a 1 to 9 scale with 1 = worst, 5 = minimally acceptable, and 9 = best tall fescue.

- Visual turfgrass color measured on a 1 to 9 scale with 1 = brown, 5 = minimally acceptable, and 9 = best dark green tall fescue color.

Turfgrass visual color and quality ratings were taken every 2 weeks on Friday, after mowing.

Drought ratings

- Percent brown leaves. Scale was 1% to 100% of total plot surface area affected.

- Percent rolled and/or wilted leaves. Scale was 1% to 100% of total plot surface area affected.

Drought ratings were always taken 2 weeks following fertilizer applications, and then monthly during each quarter. Drought ratings were taken on Fridays, prior to mowing.

Other plant measurements

- Clipping yield was measured during April, June, September, and November. Specific dates were as per calendar, but always followed fertilizer applications by 4 weeks. Clippings were collected from an area representing 17.5% of subplot surface area (two 10-ft × 21-inch passes) using a 21-inch Toro commercial rotary mower equipped with a yield box attachment. Clippings were dried at 140 °F for at least 48 h in a forced draft oven, weighed, and reported as g/35 ft^2 per 7 d.

- Clipping water content was measured concurrently with clipping yields [(fresh weight - dry weight)/dry weight)]. Clippings from yield box attachment were placed in a tared paper bag, then immediately weighed on a top-loading scale to the nearest 0.1 gram. Clippings were then dried as described above for dry weights.

- Relative leaf water content was measured periodically. Sampling was conducted between 10:30 am and 12:00 pm (after dew had evaporated). Eight to 10 fully expanded, nonsenescent, representative leaf blades were cut with scissors. Any frayed edges that resulted from mowing were cut off. Two subsamples were harvested from representative areas within each subplot. Data collected from the two subsamples were averaged together.

Leaves were immediately placed in small plastic petri dishes within a cooler, and subsequently weighed in the laboratory for fresh weight. Petri dishes were then filled with distilled water and placed in a refrigerator (39 °F) for 12 to 16 h. Water was then decanted and leaves blotted dry and weighed for rehydrated weight. Leaf tissue was then dried for 48 h at 140 °F and dry weights recorded.

RLWC was calculated as [(fresh weight - dry weight)/(rehydrated weight - dry weight)] × 100. Leaf water content was also calculated from these samples as (fresh weight-dry weight/dry weight).

Soil water tension and soil water content

- Soil water tension at 6- and 12-inch depths was measured using Watermark granular matrix sensors (Irrometer Co., Riverside, Calif.) connected to remote readers at the edge of the research plot. Sensors were located next to neutron probe access tubes in two locations within each Jaguar III subplot. Measurements from the two locations within each Jaguar III subplot were averaged. Sensors were read weekly with a Watermark Soil Moisture Meter on Tuesday and Wednesday (before and after irrigation).

- Volumetric soil water content was measured with neutron scattering (Boart Longyear CPN 503DR Hydroprobe) to a 4-ft depth (9, 12, 24, 36, 48 inches) in two locations within each Jaguar III subplot (24 locations). Measurements from the two locations within each Jaguar III subplot were averaged. Readings were taken from PVC access tubes monthly on Tuesdays. The calibration curve relating count ratio to volumetric soil water content was derived from 39 soil samples extracted from the research plot and two other plots. The equation is:

Volumetric soil water content = (36.379*count ratio) - 12.927
where $R^2 = 0.9$ and count ratio was the ratio of recorded neutron counts to a standard count measured periodically.

Climatic Information and Datalogger

- Meteorological data from a CIMIS weather station located 169 ft from the research plot included: ET_o; precipitation; solar radiation ($W{\cdot}m^{-2}$); minimum, maximum and average air temperature (°C); minimum, maximum, and average relative humidity (%); dew point (°C); average wind speed ($m{\cdot}s^{-1}$); wind run (km); and average soil temperature at a 6-inch depth.

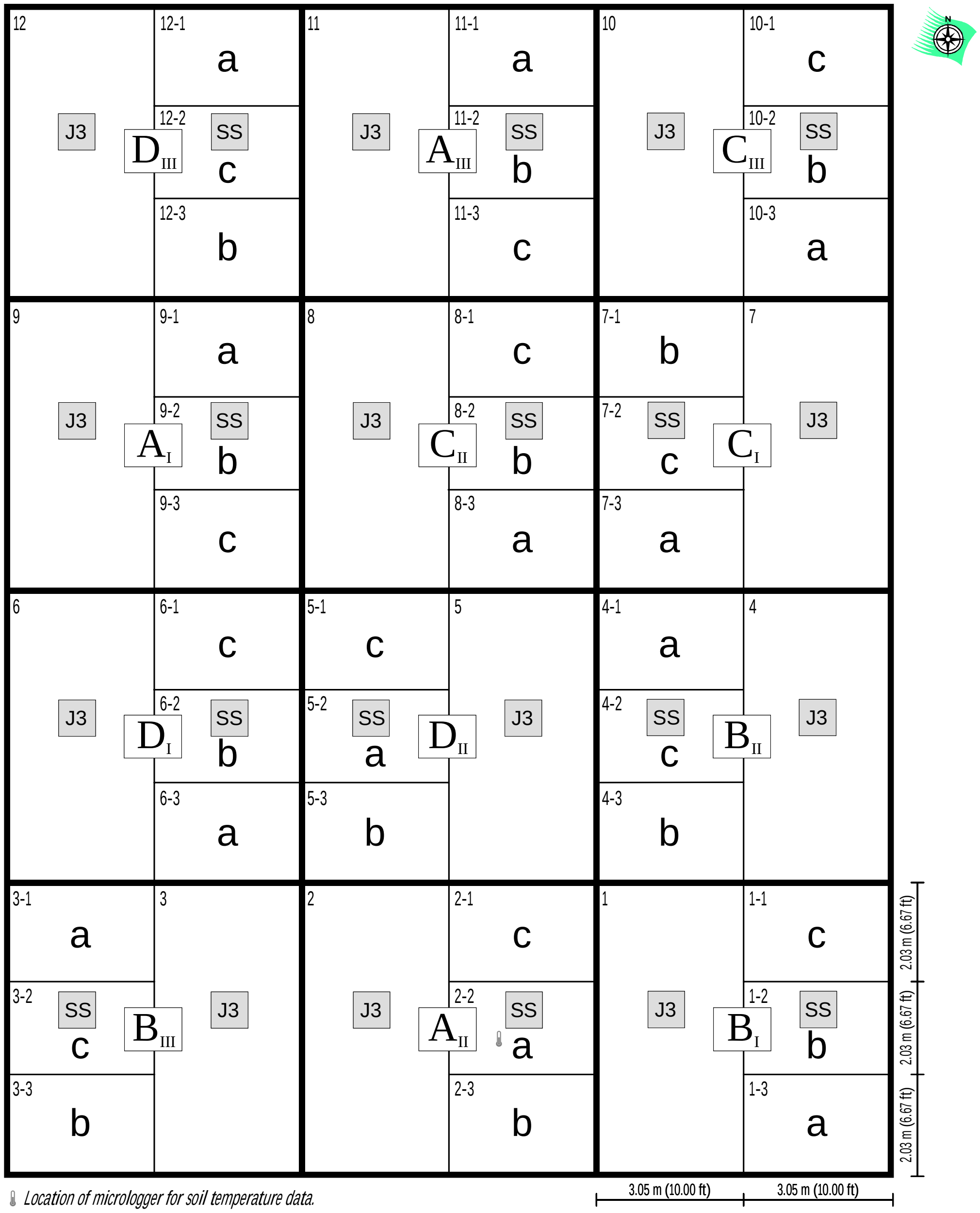
- Rainfall was recorded from a tipping bucket rain gauge connected to the adjacent CIMIS station.

- Soil temperature was measured with a temperature probe at a 4-inch depth. Data was recorded with a StowAway XTI micrologger (Onset Computer Corporation, Pocasset, Mass.) and downloaded monthly.

Statistical analyses of measurements:

All MWD data was subjected to a randomized complete block ANOVA according to the general linear models procedure of the Statistical Analysis System (SAS Institute Inc., Cary, N.C.). A repeated measures ANOVA also was performed for visual turfgrass quality and color, percent leaves rolled and/or wilted, percent brown leaves, clipping water content, RLWC, leaf water content, and soil water content and tension with date as the repeated measures factor. Means of irrigation treatments were compared by using a Fisher's Protected LSD test.

Figure 1. Plot plan for the tall fescue irrigation water banking study.



Key:

Genotype: SS = Shortstop tall fescue, J3 = Jaguar III tall fescue

Irrigation treatments – main plots [6.10 x 6.10 m (20.00 x 20.00 ft)]:
A = 80%, 80%, 80%, 80% hist. ETo
B = 58%, 90%, 90%, 58% hist. ETo (1998) or 40%, 92%, 91%, 70% hist. ETo (1999 and 2000)
C = 58%, 96%, 85%, 58% hist. ETo (1998) or 40%, 85%, 97%, 70% hist. ETo (1999 and 2000)
D = 80%, 80%, 80%, 80% ETo
I, II, III = replications (blocked according to irrigation distribution uniformity of each plot)

Fertility treatments – subplots [2.03 x 3.05 m (6.67 x 10.00 ft)]:
a = 3.0 lb N/1000 ft2 per year (1998) or 4.0 lb N/1000 ft2 per year (1999 and 2000)
b = 4.5 lb N/1000 ft2 per year (1998) or 6.0 lb N/1000 ft2 per year (1999 and 2000)
c = 6.0 lb N/1000 ft2 per year (1998) or 7.7 lb N/1000 ft2 per year (1999 and 2000)

RESULTS AND DISCUSSION

Irrigation application

Irrigation treatments were applied from 2 Apr. 1998 through 31 Dec. 2000. The plots received supplemental irrigation according to the protocol outlined in Tables 2 and 3. Data for 1998 was presented separately from 1999 and 2000 since the irrigation protocol was modified for the latter 2 years based on data from the first year.

1998 RESULTS

Table 4 provides a summary of ET_o, historical ET_o, rainfall, and applied irrigation water in 1998. Annual ET_o was 4.7% below historical ET_o, with an abundance of rainfall during the January to March period (366 mm actual vs. 141 mm historical) and a lack of rainfall during the October to December period. During the July to September and October to December periods, when no irrigation events were canceled, actual irrigation water applied was comparable to the amount of irrigation water allotted for each irrigation treatment (Table 4, compare the underlined percentage in the text of the table with the treatment percentage in the table spanner head). Annual water application for treatments A, B, and C averaged 88% ET_{crop} (73% ET_o). This was less than the recommended water allotment for cool-season grasses which averages 80% ET_o.

The Effect of Irrigation Treatment Regimes on Tall Fescue Visual Quality and Color

Table 5 provides a summary of the visual turfgrass quality and color data, in terms of the number of rating dates that have a rating $\geq$ 5.5, on a 1 to 9 scale. A rating of 5 was minimally acceptable tall fescue quality or color. A rating of 6 for visual turfgrass quality or color seems to be satisfactory to most Californians (personal observation). There was a need to effectively show trends because visual turfgrass quality data (Table 6) and visual turfgrass color data (Table 7) show that irrigation treatments were not significantly different for most rating dates.

Three trends appear in Table 5. First, during the critical 3-month quarter of July to September, the water banking treatments performed as well as or better than the 80% $ET_{o(real\text{-}time)}$ treatment. This was important because the water banking treatments required only one irrigation run time setting on 30 June, while the 80% $ET_{o(real\text{-}time)}$ treatment required weekly changes of irrigation run time. The 80% $ET_{o(real\text{-}time)}$ treatment irrigation amount was realistic because it was similar to 100% $ET_{o(real\text{-}time)}$ of most landscapes (the DU of the irrigation system of the research plots was 20% higher than the DU of the irrigation system of most landscapes). However, weekly changes of irrigation run times are probably not realistic. Yet irrigating based on real-time ET_o would require weekly changes of irrigation run times. Irrigation run times based on real-time ET_o from longer periods of time, such as the previous 4 weeks, would probably not be successful because environmental conditions, including ET_o, are too variable.

The second trend that appears in Table 5 was that the most successful treatment during the 3-month quarter of October to December was the 80% $ET_{o(real-time)}$. Not enough irrigation was allotted for the water banking treatments. Observation of historical rainfall patterns (Table 3) shows that the October to December period lacks rainfall and that more rainfall occurs during the January to March 3-month quarter. This information suggests that most irrigation water banking needs to occur during the January to March period.

The third trend that appears in Table 5 was that the treatment of irrigating tall fescue at a constant rate of 80% historical ET_o was a failure from July to December, in terms of achieving a threshold value for acceptable visual turfgrass quality and color. It was interesting to note that the annual amount of applied irrigation water for this treatment was similar to the annual amount of applied irrigation water for the irrigation water banking treatments (Table 4) and that this irrigation amount was comparable to 100% historical ET_o plus rain of most landscapes (the DU of the research plot irrigation systems was 20% higher than the irrigation system DU's of most landscapes).

<u>The Effect of Irrigation Treatment Regimes on Visual Drought Ratings, Clipping Yield, Clipping Water Content, Relative Leaf Water Content, and Leaf Water Content</u>

The data for percent leaves rolled and/or wilted (Table 8) and percent brown leaves (Table 9) show that irrigation treatments did not result in significant differences on any rating dates except the 15 Dec. rating for percent brown leaves. Data on this date show that the 58, 96, 85, 58% historical ET_o water banking treatment had the highest percent of brown leaves. Though differences were nonsignificant on other dates and for percent leaves rolled and/or wilted, a biological trend indicates that this treatment produced the highest drought ratings (highest percent wilted and/or rolled leaves and percent brown leaves) during November and December.

Clipping yield data (Table 10) show that irrigation treatments resulted in no significant differences on any measurement date except 11 Sept. Data on this date show that turf growth for the 80% historical ET_o treatment was significantly lower than the 58, 90, 90, 58% historical ET_o treatment, but not significantly different from the 58, 96, 85, 58% historical ET_o, nor the 80% $ET_{o(real-time)}$ treatments. Clipping water content data (Table 11) follow the same trend.

There were no significant differences on all dates for RLWC (Table 12). Leaf water content data (Table 13) show that irrigation treatments were significantly different on 25 Aug. and 3 Nov. and the data support the trends concerning visual turfgrass quality and color; namely that during the July to September 3-month quarter, the constant 80% historical ET_o irrigation treatment had dry leaf tissue and minimally acceptable visual turfgrass quality and color; and during the October to December period, the 80% $ET_{o(real-time)}$ irrigation treatment had moist leaf tissue and visual turfgrass quality and color ratings normally ≥ 6.

The Effect of Irrigation Treatment Regimes on Soil Water Tension and Soil Water Content

The data for soil water tension at the 6-inch depth (Table 14) and at the 12-inch depth (Table 15) show that irrigation treatments were not significantly different for most rating dates. However, soil water tension at the 12-inch depth for 18 Aug., 1 Sept. and 15 Sept. show that the 80% historical ET_o treatment had the driest soil (highest soil water tension). These data support the trend that this treatment had minimally acceptable visual turfgrass quality and color during the July to September 3-month quarter.

Neutron probe volumetric soil water content data for the 9-, 12-, 18-, 24-, 36-, and 48-inch depths are shown in Tables 16, 17, 18, 19, 20, and 21, respectively. These data show several significant trends among the irrigation treatments. First, during the April to June 3-month quarter, the soil water content at the 9- and 12-inch depths was lowest (dry) for the 80% $ET_{o(real-time)}$ irrigation treatment and highest (wet) at the 9- to 36-inch depths for the 58, 96, 85, 58% historical ET_o water banking treatment. The second significant trend was that during the July to September 3-month quarter the soil water content at the 9- to 24-inch depths was lowest (dry) for the 80% historical ET_o irrigation treatment. The third significant trend was that during the October to December 3-month quarter the soil water content at the 9-inch depth was highest (wet) for the 80% $ET_{o(real-time)}$ irrigation treatment.

The last two trends support the conclusions that 1) the 80% historical ET_o irrigation treatment produced the poorest tall fescue for the July to September 3-month quarter and 2) that the 80% $ET_{o(real-time)}$ irrigation treatment produced the best tall fescue for the October to December 3-month quarter.

Summary of 1998

Results from the first year (1998) show several trends. First, during the critical 3-month quarter of July to September, the water banking treatments performed as well as or better than the 80% $ET_{o(real-time)}$ irrigation treatment. The water banking treatments had one irrigation clock change on 1 July, while the 80% $ET_{o(real-time)}$ irrigation treatment had weekly irrigation clock changes.

Secondly, the 80% historical ET_o irrigation treatment had the poorest performance of all irrigation treatments from July to December. During the July to September quarter, the soil water content at the 9- to 24-inch depths for this treatment was lowest (dry) among all irrigation treatments.

During the October to December quarter, the only successful irrigation treatment was the 80% $ET_{o(real\text{-}time)}$. During this time, the soil water content at the 9-inch depth for this treatment was highest (wet) among all irrigation treatments. The other irrigation treatments performed poorly during the October to December quarter due to a lack of irrigation. Considering the historical rainfall patterns, more irrigation should be allotted to the water banking irrigation treatments during the October to December quarter. Based on the findings from the first year, the water banking irrigation treatments were revised for the second and third years. The revised treatments can be seen in Table 3 and were designed to bank the most water during the January to March quarter when the historical rainfall was 5.6 inches.

1999 AND 2000 RESULTS

Tables 22 and 23 provide summaries of ET_o, historical ET_o, rainfall, and applied irrigation water for the second 2 years of the study. Annual real-time ET_o was close to historical ET_o during both years (real-time ET_o was 1.9% and 2.3% higher than historical ET_o in 1999 and 2000, respectively). Actual rainfall for both years was below the historical average, i.e., both years were drier than normal. This may have resulted in reduced visual ratings and turfgrass performance during these years, however, the drier evaluation period provided a good test of the water banking treatments. Note that the annual water application each year was close to 80% historical ET_o, or 80% real-time ET_o for the historical and real-time treatments, respectively (Tables 22 and 23, rows 9 and 10 in last 4 columns of the table). Also note that actual irrigation water applied was comparable to the amount of irrigation water allotted for each irrigation treatment (Tables 22 and 23, compare the underlined percentage in the text of the table with the treatment percentage in the table spanner head.)

The Effect of Irrigation Treatment Regimes on Tall Fescue Visual Quality and Color

Tables 24 and 25 are a summary of the visual turfgrass quality and color data from 1999 and 2000 in terms of the number of rating dates that have a rating $\geq$ 5.5, on a 1 to 9 scale. A rating of 5 was minimally acceptable tall fescue quality or color. A rating of 6 for visual turfgrass quality or color seems to be satisfactory to most Californians (personal observation). In 1999 (Table 24), during the January to March quarter, there were no dates where quality or color ratings were $\geq$ 5.5 for all treatments. During the July to September quarter there were no dates where quality or color ratings were $\geq$ 5.5 for the 80% $ET_{o(real\text{-}time)}$ and 80% historical ET_o irrigation treatments. During the October to December quarter there were no quality ratings $\geq$ 5.5 for any irrigation treatment. Color ratings exceeded 5.5 only for the 40, 85, 97, 70% historical ET_o and 80% $ET_{o(real\text{-}time)}$ irrigation treatments, and this only once. A look at yearly totals for 1999 (Table 24) shows that the total number of rating dates where quality or color ratings were $\geq$ 5.5 was a fairly small percentage of the total number of rating dates. In other words, turfgrass visual quality and color for all irrigation treatments in 1999 was marginal.

Visual turfgrass ratings improved in 2000. During the July to September quarter, only the 80% $ET_{o(real\text{-}time)}$ irrigation treatment had no ratings $\geq$ 5.5. The water banking treatments 40, 92, 91, 70% historical ET_o and 40, 85, 97, 70% historical ET_o had the greatest number of ratings $\geq$ 5.5. During the October to December quarter, all treatments produced ratings $\geq$ 5.5 on all dates, the exception being that the 80% $ET_{o(real\text{-}time)}$ irrigation treatment produced only one visual quality rating $\geq$ 5.5.

A trend appears in Tables 24 and 25 which differs from the 1998 data. During the critical 3-month quarter of July to September, the water banking treatments performed better than the 80% $ET_{o(real\text{-}time)}$ treatment. This was important because the water banking treatments required only one irrigation run time setting on 30 June, while the 80% $ET_{o(real\text{-}time)}$ treatment required weekly changes of irrigation run time. The 80% $ET_{o\ (real\text{-}time)}$ treatment irrigation amount was realistic because it was similar to 100% $ET_{o(real\text{-}time)}$ of most landscapes (the DU of the irrigation system of the research plots was 20% higher than the DU of the irrigation system of most landscapes). However, weekly, or even monthly changes of irrigation run times based on real-time ET_o are probably not realistic.

A look at the visual turfgrass quality and color data from 1999 (Tables 26 and 27) does not show many differences between irrigation treatments. Accordingly, viewing the data in terms of trends as discussed above is helpful. Table 28 presents visual turfgrass quality and color data from the third year (2000) and significant differences between treatments are present on all rating dates between 4 Aug. and 13 Oct. During this critical summer period, visual quality of the two water banking treatments was consistently higher than the 80% historical ET_o and 80% $ET_{o(real\text{-}time)}$ treatments, although these differences are not significant on all dates. In terms of visual turfgrass color (Table 29), the same trend was present; however, differences are significant on fewer dates.

The Effect of Irrigation Treatment Regimes on Visual Drought Ratings, Clipping Yield, Clipping Water Content, Relative Leaf Water Content, and Leaf Water Content

The 1999 data for percent leaves rolled and/or wilted (Table 30) and percent brown leaves (Table 31) show that the most leaf rolling and/or wilting and browning occurred between June and December. During this time, irrigation treatments significantly influenced the ratings on 25 June and 24 Sept. where the 80% $ET_{o(real\text{-}time)}$ irrigation treatment resulted in the greatest amount of leaf rolling and/or wilting and browning. During 2000, both water banking treatments resulted in less leaf rolling and/or wilting on 12 May and 21 July (Table 32) and significantly less percent brown leaves compared to the 80% historical ET_o and 80% $ET_{o(real\text{-}time)}$ treatments on 21 July, 29 Sept., and 27 Oct. (Table 33).

Clipping yield data for 1999 and 2000 (Tables 34 and 35) show that cumulative yield for 1999 appeared lower than for 2000, and both years appeared to have lower cumulative yield compared to 1998 (Table 10) (note that cumulative yield for each year represented a sum of four clipping yield dates). This was probably due to the relatively wet winter preceding the first year's (1998) evaluation, and reduced rainfall preceding the second year's (1999) evaluation. A significant difference between treatments on 2 April 1999 (Table 34) indicates that turf growth was best under the 80% $ET_{o(real\text{-}time)}$ irrigation treatment, and a significant difference between treatments on 1 Sept. 2000 shows that turf growth was lowest under the 80% historical ET_o irrigation treatment (Table 35). Lack of significant differences on any other date indicate that the irrigation treatments did not strongly influence turfgrass growth in 1999 nor 2000.

Clipping water content was unaffected by irrigation treatments in 1999 (Table 36), however there were significant differences between irrigation treatments on two dates in 2000 (Table 37). Clipping water content was significantly greater for the two 80% ET_o treatments compared to the water banking treatments on 31 Mar., probably due to the fact that the water banking treatments were only applying 40% ET_o on this date. The water banking treatments as well as the 80% $ET_{o(real\text{-}time)}$ treatment produced significantly greater clipping water content compared to the 80% historical ET_o treatment on 1 Sept. This was consistent with significantly reduced clipping yields for this treatment on the same date.

Relative leaf water content for 1999 and 2000 is presented in Tables 38 and 39. The analysis for 25 Apr. and the overall for 2000 (Table 39) show that leaf water status was best for the water banking treatment 40, 92, 91, 70% historical ET_o. This supports visual turfgrass ratings for this year which indicate that turfgrass performance was best in plots irrigated with the water banking treatment 40, 92, 91, 70% historical ET_o.

Leaf water content data from 1999 and 2000 (Tables 40 and 41) show no significant differences between irrigation treatments, with the exception of 20 Apr. 1999.

The Effect of Irrigation Treatment Regimes on Soil Water Tension and Soil Water Content

The data for soil water tension at the 6-inch depth (Tables 42 and 44 for 1999 and 2000, respectively) and at the 12-inch depth (Tables 43 and 45 for 1999 and 2000, respectively) show that there were some significant differences between irrigation treatments in 1999, but few or none in 2000. The data for 1999 (Tables 42 and 43) show that during the January to March quarter, soil tensions were highest (driest) for the water banking treatments. This was to be expected since these two treatments were applying only 40% historical ET_o during this quarter, and rainfall during this quarter was less than normal. During the April to June quarter, and on 21 Sept., soil water tension became highest (drier) for the 80% $ET_{o(real\text{-}time)}$ irrigation treatment. Though significant differences are not present on 27 July and 24 Aug. (the other two measurement dates of the July to September quarter), there appears to be a biological trend with the 80% $ET_{o(real\text{-}time)}$ irrigation treatment having the driest soil.

These data support the observation that the 80% $ET_{o(real\text{-}time)}$ irrigation treatment had no ratings above 5.5 during the July to September quarter in 1999 (Table 24) and that percent rolled and/or wilted leaves and percent brown leaf ratings (Tables 30 and 31) were higher for this irrigation treatment on 24 Sept. 1999.

Neutron probe volumetric soil water content data for the 9-, 12-, 18-, 24-, 36-, and 48-inch depths in 1999 are shown in Tables 46, 47, 48, 49, 50 and 51, respectively. 2000 data for the same depths are shown in Tables 52, 53, 54, 55, 56, and 57. The general trend apparent from both years' data is that volumetric soil water content measurements between April and December were highest (wettest) for the 40, 85, 97, 70% historical ET_o irrigation treatment and were lowest (driest) for the 80% $ET_{o(real\text{-}time)}$ irrigation treatment. This trend was consistent for all depths to 36 inches. No significant differences in soil water content between irrigation treatments were present at the 48-inch depth. Our irrigation treatments were not likely affecting soil water content at this depth. The most dramatic differences between treatments occurred both years at the 36-inch depth (Tables 50 and 56). In 1999, soil water content for the 40, 85, 97, 70% historical ET_o irrigation treatment was significantly higher than all other treatments between 27 July and 19 Oct. Data from 2000 show that soil water content was significantly higher for this treatment compared to the other treatments on all dates (except 29 Aug.) between 21 Mar. and 19 Dec., and the overall. On most of these dates there were no significant differences between the remaining irrigation treatments, although the 80% $ET_{o(real\text{-}time)}$ and 80% historical ET_o were consistently lower (driest). These data are consistent with the first year (1998) data inasmuch as soil water content was highest in the water banking treatment plots, and lowest in the 80% $ET_{o(real\text{-}time)}$ and 80% historical ET_o plots. Volumetric soil water content data support the conclusions that the 80% $ET_{o(real\text{-}time)}$ and 80% historical ET_o irrigation treatments produced the poorest tall fescue during the April to June and July to September quarters, while the water banking treatments, particularly the 40, 85, 97, 70% historical ET_o irrigation treatment produced the best tall fescue performance during these quarters.

FINAL CONCLUSIONS

Yearly allotment of irrigation water allows for "water banking," i.e., increased irrigation during the warm season to improve grass performance, and then proportionally adjusting the cool-season irrigation amount downward to compensate for the addition of warm-season irrigation. Data from this 3-year study indicates that tall fescue performance can be improved, depending on how the annual 80% historical ET_o allotment of irrigation water is proportioned. The following general observations and conclusions arose from this study:

1. The annual allotment of 80% ET_o produced better visual turfgrass quality in 1998 than in 1999 and 2000. This was most likely due to below-average rainfall during the latter 2 years. However, it should be noted that an annual allotment of 80% ET_o is not sufficient water to maintain tall fescue in Riverside. Also, it should be noted that 80% ET_o is equal to approximately 100% ET_o in the industry because irrigation system DU of the research plots may be 20% higher than the DU of typical landscape sites.

2. The water banking treatments were adjusted after the 1998 study because it was determined that more water could be "banked" during the January to March quarter, and more water was needed during the October to December quarter. These adjustments improved the performance of the water banking treatments in 2000.

3. During the critical July to September quarter, the water banking treatments performed as well as the 80% $ET_{o(real\text{-}time)}$ treatment in 1998 and better than this treatment in 1999 and 2000. Better visual ratings for the water banking treatments are supported by lower soil water tension and higher soil water content, particularly at the 36-inch depth. This is significant because the water banking treatments required only one irrigation run time setting for the quarter, while the 80% $ET_{o(real\text{-}time)}$ treatment required weekly controller programming. The former scenario is more consistent with industry practice.

4. The treatment of irrigating tall fescue at a constant rate of 80% historical ET_o was inferior to the water banking treatments from July to September during all 3 years. Superior performance of the water banking treatments compared to both 80% ET_o treatments is also apparent when dates where visual turfgrass quality and color ratings were $\geq$5.5 are added for the 3 years for the July to September quarter (Table 58).

5. Considering annual performance, the worst irrigation treatment was the constant rate of 80% historical ET_o in 1998, while the 80% $ET_{o(real\text{-}time)}$ was the worst treatment in 2000.

6. Although visual ratings did not differ significantly between the two water banking treatments, soil water content at the 36-inch depth, was highest for the 40, 85, 97, 70% irrigation regime on many dates in 1999 and 2000 suggesting that this treatment may be slightly better than the 40, 92, 91, 70% treatment.

Table 2. Protocol for 1998 for three irrigation treatments based on a percentage of historical reference ET_o for four quarterly (3-month) periods and one irrigation treatment based on real-time ET_o for 12 months.

Month	Monthly historical ET_o (inch)[z]	Quarter	Quarterly historical ET_o (inch)[z]	Irrigation treatment[y] A	B	C	D	Fertilization: Date of application	Source of N	Rate (lb N/1000 ft^2)
Jan.	2.07	1								
Feb.	2.87	1	8.97	80% ET_o (7.18 inch)	58% ET_o (5.20 inch)	58% ET_o (5.20 inch)	80% ET_o (real-time)	1 Mar.	$CaNO_3$	1.125
Mar.	4.03	1								
Apr.	4.13	2								
May	6.10	2	17.32	80% ET_o (13.86 inch)	90% ET_o (15.59 inch)	96% ET_o (16.63 inch)	80% ET_o (real-time)	15 May	NH_4NO_3	1.125
June	7.09	2								
July	7.93	3								
Aug.	7.57	3	21.64	80% ET_o (17.31 inch)	90% ET_o (19.48 inch)	85% ET_o (18.39 inch)	80% ET_o (real-time)	15 Aug.	NH_4NO_3	1.125
Sep.	6.14	3								
Oct.	4.15	4								
Nov.	2.60	4	8.70	80% ET_o (6.96 inch)	58% ET_o (5.05 inch)	58% ET_o (5.05 inch)	80% ET_o (real-time)	15 Oct.	$CaNO_3$	1.125
Dec.	1.95	4								
Total	56.63		56.63	45.31 inch	45.32 inch	45.27 inch	TBD[x]			4.5

[z]Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see page 62).

[y]The MWD portion of this study was a randomized complete block design, with irrigation treatments assigned to 20.0 x 20.0 ft main plots that were arranged in three randomized complete blocks (Fig. 1). However, all plant and soil measurements for the MWD project were collected from the Jaguar III subplots. Treatment A reflects an annual average cool-season turfgrass crop coefficient of 0.8, while treatments B and C reflect adjustments to this annual average. These treatments were based on the 3-month allotment and scheduled utilizing the application rates of each main plot and the total number of irrigation events per quarter (irrigation run times were set the first day of each three-month period). Treatment D was based on the previous 7-d cumulative ET_o (from an on-site CIMIS station 169 ft from the research plot) and was scheduled utilizing the application rates of each main plot and the two irrigation events per week (irrigation run times were set weekly on Tuesdays). All treatments were applied in two irrigation events per week–Saturday and Wednesday morning before sunrise. Irrigation events for all treatments were cycled to prevent runoff. Rain was not subtracted from either the three-month or weekly allotment but may have resulted in cancellation of an irrigation event.

[x]TBD = to be determined.

Table 3. Protocol for 1999 and 2000 for three irrigation treatments based on a percentage of historical reference ET_O for four, quarterly (3-month) periods and one irrigation treatment based on real-time ET_o for 12 months.

Month	Monthly historical ET_o (inch)[z]	Monthly historical rainfall (inch)[y]	Quarter	Quarterly historical ET_o (inch)[z]	Irrigation treatment (percentage of ET_o and resulting application depth)[x]				Fertilization		
					A	B	C	D	Date of application	Source of N $N\text{-}P_2O_5\text{-}K_2O$	Rate (lb N/1000 ft^2)
Jan.	2.07	1.85	1								
Feb.	2.87	2.05	1	8.97	80% ET_o (7.18 inch)	40% ET_o (3.59 inch)	40% ET_o (3.59 inch)	80% ET_o (real-time)	1 Mar.	Polyon 43-0-0	1.5
March	4.03	1.65	1								
April	4.13	1.02	2								
May	6.10	0.28	2	17.32	80% ET_o (13.86 inch)	92% ET_o (15.93 inch)	85% ET_o (14.72 inch)	80% ET_o (real-time)	15 May	Polyon 42-0-0	1.5
June	7.09	0.04	2								
July	7.93	0.00	3								
Aug.	7.57	0.12	3	21.64	80% ET_o (17.31 inch)	91% ET_o (19.69 inch)	97% ET_o (20.99 inch)	80% ET_o (real-time)	15 Aug.	Polyon 42-0-0	1.5
Sep.	6.14	0.20	3								
Oct.	4.15	0.39	4								
Nov.	2.60	1.02	4	8.70	80% ET_o (6.96 inch)	70% ET_o (6.09 inch)	70% ET_o (6.09 inch)	80% ET_o (real-time)	15 Oct.	Polyon 43-0-0	1.5
Dec.	1.95	1.81	4								
Total	56.63	10.43		56.63	45.31 inch	45.30 inch	45.39 inch	TBD[w]			6.0

[z]Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see page 62).

[y]Anonymous. 1981. California rainfall summary, monthly total precipitation, 1949-1980. SDWR. 54 pp. plus microfiche.

[x]The MWD portion of this study was a randomized complete block design, with irrigation treatments assigned to 20.0 x 20.0 ft main plots that were arranged in three randomized complete blocks (Fig. 1). However, all plant and soil measurements for the MWD project were collected from the Jaguar III subplots. Treatment A reflects an annual average cool-season turfgrass crop coefficient of 0.8, while treatments B and C reflect adjustments to this annual average. These treatments were based on the 3-month allotment and scheduled utilizing the application rates of each main plot and the total number of irrigation events per quarter (irrigation run times were set the first day of each 3-month period). Treatment D was based on the previous 7-d cumulative ET_o (from an on-site CIMIS station169 ft from the research plot) and was scheduled utilizing the application rates of each main plot and the two irrigation events per week (irrigation run times were set weekly on Tuesdays). All treatments were applied in two irrigation events per week–Saturday and Wednesday morning before sunrise. Irrigation events for all treatments were cycled to prevent runoff. Rain was not subtracted from either the3-month or weekly allotment but may have resulted in cancellation of an irrigation event.

[w]TBD = to be determined.

Table 4. Summary of ET_o and historical ET_o, rainfall, and applied irrigation water in 1998.

	Variable	1998 Quarter: January to March — Irrigation treatment (% quarterly ET_o)				April to June — Irrigation treatment (% quarterly ET_o)				July to September — Irrigation treatment (% quarterly ET_o)				October to December — Irrigation treatment (% quarterly ET_o)				1998: January to December — Irrigation treatment (% quarterly ET_o)			
		A (80% hist. ET_o)[z]	B (58% hist. ET_o)	C (58% hist. ET_o)	D (80% ET_o)[y]	A (80% hist. ET_o)[z]	B (90% hist. ET_o)	C (96% hist. ET_o)	D (80% ET_o)[y]	A (80% hist. ET_o)[z]	B (90% hist. ET_o)	C (85% hist. ET_o)	D (80% ET_o)[y]	A (80% hist. ET_o)[z]	B (58% hist. ET_o)	C (58% hist. ET_o)	D (80% ET_o)[y]	A (80,80, 80, 80% hist. ET_o)[z]	B (58,90, 90, 58% hist. ET_o)	C (58,96, 85, 58% hist. ET_o)	D (80,80, 80, 80% ET_o)[y]
1)	Real-time ET_o (mm)	195	195	195	195	418	418	418	418	513	513	513	513	245	245	245	245	1371	1371	1371	1371
2)	Historical ET_o (mm)	228	228	228	228	440	440	440	440	550	550	550	550	221	221	221	221	1439	1439	1439	1439
3)	ET_{crop} ($ET_o \times K_c$ month) (mm)	134	134	134	134	399	399	399	399	441	441	441	441	169	169	169	169	1143	1143	1143	1143
4)	Rainfall (mm)	366	366	366	366	43	43	43	43	14	14	14	14	24	24	24	24	447	447	447	447
5)	Historical rainfall (mm)[x]	141	141	141	141	34	34	34	34	8	8	8	8	82	82	82	82	265	265	265	265
6)	Applied water (mm)[w]	53	60	60	66	296	336	358	219	444	497	466	433	178	128	131	201	971	1021	1015	919
7)	Total water (rainfall plus applied) (mm)	419	426	426	432	339	379	401	262	458	511	480	447	202	152	155	225	1418	1468	1462	1366
8)	(Applied water/ET_{crop}) ×100	40	45	45	49	74	84	90	55	101	113	106	98	105	76	78	119	85	89	89	80
9)	(Applied water/real-time ET_o) × 100	27	31	31	34	71	80	86	52	87	97	91	84	73	52	53	82	71	74	74	67
10)	(Applied water/historical ET_o) × 100	23	26	26	29	67	76	81	50	81	90	85	79	81	58	59	91	67	71	71	64
11)	No. irrigation events	10	10	10	10	22	22	22	19	27	27	27	27	26	26	26	26	85	85	85	82
12)	No. irrigation events canceled	16	16	16	16	4	4	4	7	0	0	0	0	0	0	0	0	20	20	20	23

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Anonymous. 1981. California summary, monthly total precipitation, 1949-1980. SDWR. 54 pp. plus microfiche.
[w]Applied water was calculated as (actual water time per day / system precipitation rate) x no. irrigation events. Numbers for each irrigation treatment were calculated as the average of three replicate plots.

Note: Within each column, underlined percentages can be compared to the percentages that are listed directly below the letters (A, B, C, D) that designate irrigation treatments.

Table 5. The effect of four irrigation treatment regimes and three 3-month periods in 1998 on the number of rating dates that tall fescue visual quality and color was ≥ 5.5.

3-month period in 1998: Number rating dates	Irrigation treatment			
	80, 80, 80, 80% historical ET_o Treatment A	58, 90, 90, 58% historical ET_o Treatment B	58, 96, 85, 58% historical ET_o Treatment C	80, 80, 80, 80% real-time ET_o Treatment D
April to June				
No. of rating dates	7	7	7	7
No. dates:				
Quality ≥ 5.5	7	7	7	7
Color ≥ 5.5	7	7	7	7
July to September				
No. of rating dates	7	7	7	7
No. dates:				
Quality ≥ 5.5	2	7	7	6
Color ≥ 5.5	5	7	7	7
October to December				
No. of rating dates	6	6	6	6
No. dates:				
Quality ≥ 5.5	2	4	1	6
Color ≥ 5.5	5	5	1	6
1998 totals: April to December				
No. of rating dates	20	20	20	20
No. dates:				
Quality ≥ 5.5	11	18	15	19
Color ≥ 5.5	17	19	15	20

Table 6. The effect of irrigation level treatment on visual turfgrass quality of tall fescue in 1998 (1 to 9 scale, with 1= worst, 5=minimally acceptable, and 9=best tall fescue).

Irrigation treatment	Date																				Over-all
	3 Apr.	17 Apr.	1 May	15 May	29 May	12 June	26 June	10 July	24 July	7 Aug.	21 Aug.	28 Aug.	4 Sept.	18 Sept.	2 Oct.	16 Oct.	30 Oct.	13 Nov.	11 Dec.	18 Dec.	
80, 80, 80, 80% historical ET_o[z]	6.8	6.6	5.8	5.8	6.2	6.4	6.3	6.5	6.1	4.9	5.4	5.4	5.1	5.2	6.8	5.3	5.3	5.8	5.3	5.4	5.8
58, 90, 90, 58% historical ET_o	6.8	6.7	5.8	5.9	6.2	6.2	6.3	6.5	6.5	6.3	6.5	6.6	6.3	6.3	6.7	5.3	5.6	6.1	5.5	5.4	6.2
58, 96, 85, 58% historical ET_o	6.8	6.5	5.7	5.8	6.2	6.6	6.4	6.6	6.6	6.0	6.6	6.1	6.3	6.1	6.3	5.1	5.2	5.3	5.2	4.9	6.0
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	6.8	6.6	5.5	5.9	6.3	6.4	6.5	6.5	6.1	5.4	6.7	5.9	6.3	6.3	6.5	5.9	6.9	6.0	6.0	5.8	6.2
LSD, *P*=0.05	NS	NS	NS	NS	NS	0.1	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.6	0.9	NS	NS	NS	NS
Summary of ANOVA effects[x]																					
Irrigation (I)	NS	NS	NS	NS	NS	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	**	NS	NS	NS	NS
Date (D)																					***
I × D																					***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 7. The effect of irrigation level treatment on visual turfgrass color of tall fescue in 1998 (1 to 9 scale, with 1= brown, 5=minimally acceptable, and 9=darkest green tall fescue color).

	Date																				
Irrigation treatment	3 Apr.	17 Apr.	1 May	15 May	29 May	12 June	26 June	10 July	24 July	7 Aug.	21 Aug.	28 Aug.	4 Sept.	18 Sept.	2 Oct.	16 Oct.	30 Oct.	13 Nov.	11 Dec.	18 Dec.	Over-all
80, 80, 80, 80% historical ET_o[z]	6.7	6.4	5.6	5.8	6.3	6.4	6.3	6.6	6.4	5.2	5.7	5.6	5.2	5.5	6.8	5.4	5.5	5.6	5.5	5.6	5.9
58, 90, 90, 58% historical ET_o	6.6	6.4	5.6	5.7	6.2	6.3	6.3	6.4	6.3	6.4	6.6	6.8	6.3	6.3	6.8	5.4	5.8	5.8	5.6	5.6	6.1
58, 96, 85, 58% historical ET_o	6.8	6.4	5.6	5.8	6.2	6.5	6.3	6.7	6.5	6.2	6.6	6.2	6.4	6.0	6.2	5.1	5.2	5.2	5.2	4.9	6.0
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	6.8	6.5	5.7	5.8	6.2	6.4	6.3	6.5	6.1	5.5	6.9	6.1	6.5	6.4	6.3	6.0	6.9	6.2	6.2	5.8	6.2
LSD, *P*=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.9	NS	NS	0.4	0.8	NS	0.4	0.5	NS
Summary of ANOVA effects[z]																					
Irrigation (I)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	**	**	NS	**	*	NS
Date (D)																					***
I × D																					***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 8. The effect of irrigation level treatment on percent leaves rolled and/or wilted in 1998.

Irrigation treatment	Date									
	17 Apr.	29 May	12 June	24 July	28 Aug.	18 Sept.	6 Nov.	24 Nov.	15 Dec.	Overall
80, 80, 80, 80% historical ET_o[z]	0	0	0	22	70	32	42	25	32	25
58, 90, 90, 58% historical ET_o	0	0	0	0	2	0	8	15	28	6
58, 96, 85, 58% historical ET_o	0	0	0	0	27	3	50	47	77	23
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	0	2	0	28	33	18	5	5	15	12
LSD, P=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]										
Irrigation (I)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Date (D)										***
I × D										***

[z]Historical ET_o. Goldhamer, D.A. and R. L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 9. The effect of irrigation level treatment on percent brown leaves in 1998.

Irrigation treatment	Date									
	17 Apr.	29 May	12 June	24 July	28 Aug.	18 Sept.	6 Nov.	24 Nov.	15 Dec.	Overall
80, 80, 80, 80% historical ET_o[z]	0	0	0	13	52	18	15	8	2	12
58, 90, 90, 58% historical ET_o	0	0	0	0	0	0	3	3	3	1
58, 96, 85, 58% historical ET_o	0	0	0	0	12	3	32	25	18	10
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	0	2	0	33	18	8	0	0	2	7
LSD, P=0.05	NS	NS	NS	NS	NS	NS	NS	NS	11	NS
Summary of ANOVA effects[x]										
Irrigation (I)	NS	NS	NS	NS	NS	NS	NS	NS	*	NS
Date (D)										**
I × D										**

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.

[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 10. The effect of irrigation level treatment on clipping yield[z] in 1998.

Irrigation treatment	Date: 3 Apr.	19 June	11 Sept.	13 Nov.	1998 Cumulative yield
80, 80, 80, 80% historical ET_o[y]	62.8	74.8	42.6	13.3	193.4
58, 90, 90, 58% historical ET_o	61.3	68.7	73.0	18.1	221.1
58, 96, 85, 58% historical ET_o	65.3	72.2	60.6	15.7	213.7
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[x]	64.4	65.4	60.5	20.9	211.2
LSD, P=0.05	NS	NS	19.5	NS	NS
Summary of ANOVA effects[w]					
Irrigation	NS	NS	*	NS	NS

[z]Clipping yield measured as g/33.3 ft^2 of dry clippings per 7 days growth.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 11. The effect of irrigation level treatment on clipping water content[z] in 1998.

Irrigation treatment	Date: 3 Apr.	19 June	11 Sept.	13 Nov.	Overall
80, 80, 80, 80% historical ET_o[y]	2.35	2.29	1.68	1.14	1.86
58, 90, 90, 58% historical ET_o	2.35	2.41	2.47	1.46	2.17
58, 96, 85, 58% historical ET_o	2.32	2.20	2.20	1.19	1.98
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[x]	2.37	2.01	2.13	1.60	2.03
LSD, P=0.05	NS	NS	0.41	NS	NS
Summary of ANOVA effects[w]					
Irrigation	NS	NS	*	NS	NS
Date (D)					***
I × D					***

[z] Clipping water content calculated as: (fresh wt-dry wt)/dry wt.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 12. Tall fescue relative leaf water content[z] for four irrigation treatments in 1998.

Irrigation treatment	Date: 11 May	16 June	25 Aug.	3 Nov.	Overall
80, 80, 80, 80% historical ET_o[y]	92.3	95.1	91.1	93.9	93.3
58, 90, 90, 58% historical ET_o	97.5	93.4	97.8	96.4	96.1
58, 96, 85, 58% historical ET_o	98.1	96.2	96.0	93.6	96.0
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[x]	97.4	96.0	95.7	97.7	96.7
LSD, P=0.05	NS	NS	NS	NS	NS
Summary of ANOVA effects[w]					
Irrigation (I)	NS	NS	NS	NS	NS
Date (D)					NS
I × D					NS

[z]Relative leaf water content calculated as: [(fresh wt-dry wt)/(rehydrated wt-dry wt)]*100.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
NS,*,**,***Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 13. Tall fescue leaf water content[z] for four irrigation treatments in 1998.

Irrigation treatment	Date: 11 May	16 June	25 Aug.	3 Nov.	Overall
80, 80, 80, 80% historical ET_o[y]	3.5	3.9	3.3	3.1	3.4
58, 90, 90, 58% historical ET_o	3.6	4.0	4.1	3.5	3.8
58, 96, 85, 58% historical ET_o	3.6	3.9	3.8	3.2	3.6
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[x]	3.5	3.9	3.7	3.8	3.7
LSD, P=0.05	NS	NS	0.2	0.4	NS
Summary of ANOVA effects[w]					
Irrigation (I)	NS	NS	**	*	NS
Date (D)					**
I × D					**

[z] Leaf water content calculated as: (fresh wt-dry wt)/dry wt.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
NS,*,**,***Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 14. The effect of irrigation level treatment on soil water tension as measured with Watermark granular matrix sensors at the 6-inch depth in 1998.

Irrigation treatment	Date																		Over-all
	14 Apr.	28 Apr.	12 May	26 May	2 June	16 June	30 June	7 July	21 July	4 Aug.	18 Aug.	1 Sept.	15 Sept.	29 Sept.	13 Oct.	27 Oct.	10 Nov.	24 Nov.	
	KPa																		
80, 80, 80, 80% historical ET_o[z]	7	14	10	35	25	16	29	22	28	28	17	57	27	20	30	62	62	73	31
58, 90, 90, 58% historical ET_o	9	12	11	35	25	16	17	13	13	14	12	18	11	17	41	88	92	97	30
58, 96, 85, 58% historical ET_o	11	12	9	29	17	39	14	15	15	17	12	17	11	9	27	56	73	93	26
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	19	20	15	39	17	27	42	25	38	45	13	25	22	27	35	32	22	22	27
LSD, P=0.05	3	NS	4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]																			
Irrigation (I)	***	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Date (D)																			***
I x D																			***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 15. The effect of irrigation level treatment on soil water tension as measured with Watermark granular matrix sensors at the 12-inch depth in 1998.

Irrigation treatment	14 Apr.	28 Apr.	12 May	26 May	2 June	16 June	30 June	7 July	21 July	4 Aug.	18 Aug.	1 Sept.	15 Sept.	29 Sept.	13 Oct.	27 Oct.	10 Nov.	24 Nov.	Over-all
	KPa																		
80,80,80,80% historical ET_o[z]	4	9	8	19	19	24	39	34	46	77	71	100	112	105	43	67	79	89	52
58,90,90,58% historical ET_o	6	8	6	17	20	16	19	14	18	12	6	13	8	37	15	42	50	59	21
58, 96, 85, 58% historical ET_o	5	7	4	17	15	47	10	12	25	29	20	28	13	38	17	45	66	83	27
80,80,80,80% $ET_{o\ (real\text{-}time)}$[y]	13	20	26	23	22	44	68	44	57	68	22	30	31	36	43	30	25	31	35
LSD, *P*=0.05	3	NS	NS	NS	NS	NS	33	NS	NS	NS	24	28	38	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]																			
Irrigation (I)	**	NS	NS	NS	NS	NS	*	NS	NS	NS	**	***	**	NS	NS	NS	NS	NS	NS
Date (D)																			***
I x D																			***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.

[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 16. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 9-inch depth in 1998.

Irrigation treatment	Date								
	21 Apr.	21 May	23 June	24 July	18 Aug.	22 Sept.	20 Oct.	25 Nov.	Overall
	cm^3 H_2O/cm^3 soil x 100								
80, 80, 80, 80% historical ET_o[z]	18.8	18.1	15.0	10.3	10.1	10.8	9.7	8.2	12.6
58, 90, 90, 58% historical ET_o	17.8	18.0	16.9	17.5	17.9	18.5	9.2	8.8	15.5
58, 96, 85, 58% historical ET_o	20.2	20.3	16.3	17.1	17.4	18.3	12.0	9.5	16.4
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	13.9	16.7	14.8	12.0	15.1	15.1	15.4	15.6	14.8
LSD, P=0.05	2.1	1.6	NS	5.3	5.2	5.5	NS	4.1	2.5
Summary of ANOVA effects[x]									
Irrigation (I)	**	**	NS	*	*	*	NS	**	*
Date (D)									***
I × D									***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.

[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 17. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 12-inch depth in 1998.

	Date								
Irrigation treatment	21 Apr.	21 May	23 June	24 July	18 Aug.	22 Sept.	20 Oct.	25 Nov.	Overall
	cm³ H₂O/cm³ soil x 100								
80, 80, 80, 80% historical ET_o[z]	19.3	19.1	14.9	10.6	9.9	10.4	10.5	9.0	13.0
58, 90, 90, 58% historical ET_o	18.7	18.8	17.4	17.7	18.7	18.0	12.8	10.7	16.6
58, 96, 85, 58% historical ET_o	21.1	21.5	17.1	17.3	17.2	18.3	14.2	11.4	17.3
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	14.5	18.2	15.4	12.9	15.6	15.7	16.1	15.8	15.5
LSD, P=0.05	2.1	1.8	NS	5.0	5.6	NS	NS	NS	NS
Summary of ANOVA effects[x]									
Irrigation (I)	***	*	NS	*	*	NS	NS	NS	NS
Date (D)									***
I × D									*

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 18. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 18-inch depth in 1998.

Irrigation treatment	Date: 21 Apr.	21 May	23 June	24 July	18 Aug.	22 Sept.	20 Oct.	25 Nov.	Overall
	cm^3 H_2O/cm^3 soil x 100								
80, 80, 80, 80% historical ET_o[z]	20.7	21.5	17.1	13.1	11.9	11.5	13.1	11.5	15.1
58, 90, 90, 58% historical ET_o	20.2	20.3	18.2	17.8	19.8	20.3	17.9	14.9	18.7
58, 96, 85, 58% historical ET_o	22.1	22.6	18.7	18.6	17.4	18.5	15.6	14.5	18.5
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	18.0	20.4	16.8	13.9	16.5	16.8	17.1	17.1	17.1
LSD, P=0.05	2.3	NS	NS	NS	4.7	4.7	NS	NS	NS
Summary of ANOVA effects[x]									
Irrigation (I)	*	NS	NS	NS	*	*	NS	NS	NS
Date (D)									***
I × D									**

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 19. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 24-inch depth in 1998.

Irrigation treatment	Date: 21 Apr.	21 May	23 June	24 July	18 Aug.	22 Sept.	20 Oct.	25 Nov.	Overall
	cm³ H₂O/cm³ soil x 100								
80,80,80,80% historical ET_o[z]	20.5	21.1	16.9	14.4	12.6	11.7	12.8	11.8	15.2
58,90,90,58% historical ET_o	19.6	20.7	18.3	17.3	19.0	19.7	18.6	16.4	18.7
58,96,85,58% historical ET_o	21.4	22.2	18.1	18.7	17.7	17.2	16.2	15.4	18.4
80,80,80,80% $ET_{o\ (real\text{-}time)}$[y]	18.9	19.6	17.3	13.9	15.1	15.0	15.8	15.6	16.4
LSD, P=0.05	NS	NS	NS	NS	NS	4.4	NS	NS	NS
Summary of ANOVA effects[x]									
Irrigation (I)	NS	NS	NS	NS	NS	*	NS	NS	NS
Date (D)									***
I × D									**

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 20. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 36-inch depth in 1998.

Irrigation treatment	Date: 21 Apr.	21 May	23 June	24 July	18 Aug.	22 Sept.	20 Oct.	25 Nov.	Overall
	cm³ H₂O/cm³ soil x 100								
80, 80, 80, 80% historical ET_o[z]	15.1	15.6	12.9	12.7	11.2	10.5	11.9	10.2	12.5
58, 90, 90, 58% historical ET_o	14.1	14.5	12.1	11.8	12.2	13.0	12.5	11.1	12.6
58, 96, 85, 58% historical ET_o	17.9	18.5	14.6	15.8	15.3	14.8	15.0	14.0	15.8
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	14.3	14.0	13.6	11.1	10.9	10.6	11.1	10.5	12.0
LSD, P=0.05	1.7	2.2	NS	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]									
Irrigation (I)	**	**	NS	NS	NS	NS	NS	NS	NS
Date (D)									***
I × D									NS

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 21. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 48-inch depth in 1998.

Irrigation treatment	Date: 21 Apr.	21 May	23 June	24 July	18 Aug.	22 Sept.	20 Oct.	25 Nov.	Overall
	cm^3 H_2O/cm^3 soil x 100								
80, 80, 80, 80% historical ET_o[z]	14.2	15.1	13.1	12.6	11.9	11.9	12.7	11.3	12.8
58, 90, 90, 58% historical ET_o	13.1	14.1	11.2	10.9	11.0	11.8	11.8	10.9	11.8
58, 96, 85, 58% historical ET_o	17.7	17.1	13.1	14.5	13.9	13.3	12.7	13.1	14.4
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	14.8	14.8	15.0	12.7	13.0	12.7	13.4	12.7	13.6
LSD, *P*=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]									
Irrigation (I)	NS	NS	NS	NS	NS	NS	NS	NS	NS
Date (D)									**
I × D									NS

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d cumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block statistical effects by date and overall ANOVA via repeated measures design.
[NS,*,**,***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 22. Summary of ET_o and historical ET_o, rainfall, and applied irrigation water in 1999.

	1999 Quarter																1999 Annual			
	January to March				April to June				July to September				October to December				January to December			
	Irrigation treatment (% quarterly ET_o)				Irrigation treatment (% quarterly ET_o)				Irrigation treatment (% quarterly ET_o)				Irrigation treatment (% quarterly ET_o)				Irrigation treatment (% quarterly ET_o)			
Variable	A (80% hist. ET_o)^z	B (40% hist. ET_o)	C (40% hist. ET_o)	D (80% ET_o)^y	A (80% hist. ET_o)^z	B (92% hist. ET_o)	C (85% hist. ET_o)	D (80% ET_o)^y	A (80% hist. ET_o)^z	B (91% hist. ET_o)	C (97% hist. ET_o)	D (80% ET_o)^y	A (80% hist. ET_o)^z	B (70% hist. ET_o)	C (70% hist. ET_o)	D (80% ET_o)^y	A (80,80, 80, 80% hist. ET_o)^z	B (40,92, 91,70% hist. ET_o)	C (40,85, 97,70% hist. ET_o)	D (80,80, 80, 80% ET_o)^y
1) Real-time ET_o (mm)	245	245	245	245	411	411	411	411	518	518	518	518	291	291	291	291	1465	1465	1465	1465
2) Historical ET_o (mm)	228	228	228	228	440	440	440	440	550	550	550	550	221	221	221	221	1439	1439	1439	1439
3) ET_{crop} ($ET_o \times K_c$ month) (mm)	166	166	166	166	389	389	389	389	436	436	436	436	201	201	201	201	1192	1192	1192	1192
4) Rainfall (mm)	48	48	48	48	58	58	58	58	3	3	3	3	38	38	38	38	147	147	147	147
5) Historical rainfall (mm)^x	141	141	141	141	34	34	34	34	8	8	8	8	82	82	82	82	265	265	265	265
6) Applied water (mm)^w	184	90	94	202	357	423	367	319	438	498	525	418	173	154	162	232	1152	1165	1148	1171
7) Total water (rainfall plus applied) (mm)	232	138	142	250	415	481	425	377	441	501	528	421	211	192	200	270	1299	1312	1295	1318
8) (Applied water/ET_{crop}) x 100	111	54	57	122	92	109	94	82	100	114	120	96	86	77	81	115	97	98	96	98
9) (Applied water/real-time ET_o) x 100	75	37	38	82	87	103	89	78	85	96	101	81	59	53	56	80	79	80	78	80
10) (Applied water/historical ET_o) x 100	81	39	41	89	81	96	83	73	80	91	95	76	78	70	73	105	80	81	80	81
11) No. irrigation events	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	104	104	104	104
12) No. irrigation events canceled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

^{z}Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

^{y}Real-time ET_o based on 7-dcumulative ET_o from an on-site CIMIS station approximately 169 ft from the center of the research plot.

^{x}Anonymous. 1981. California summary, monthly total precipitation, 1949-1980. SDWR. 54 pp. plus microfiche.

^{w}Applied water was calculated as (actual water time per day / system precipitation rate) x no. irrigation events. Numbers for each irrigation treatment were calculated as the average of three replicate plots.

Note: Within each column, underlined percentages can be compared to the percentages that are listed directly below the letters (A, B, C, D) that designate irrigation treatments.

Table 23. Summary of ET_o and historical ET_o, rainfall, and applied irrigation water in 2000.

	2000 Quarter																2000			
	January to March				April to June				July to September				October to December				January to December			
	Irrigation treatment (% quarterly ET_o)				Irrigation treatment (% quarterly ET_o)				Irrigation treatment (% quarterly ET_o)				Irrigation treatment (% quarterly ET_o)				Irrigation treatment (% quarterly ET_o)			
Variable	A (80% hist. ET_o)[z]	B (40% hist. ET_o)	C (40% hist. ET_o)	D (80% ET_o)[y]	A (80% hist. ET_o)[z]	B (92% hist. ET_o)	C (85% hist. ET_o)	D (80% ET_o)[y]	A (80% hist. ET_o)[z]	B (91% hist. ET_o)	C (97% hist. ET_o)	D (80% ET_o)[y]	A (80% hist. ET_o)[z]	B (70% hist. ET_o)	C (70% hist. ET_o)	D (80% ET_o)[y]	A (80,80, 80, 80% hist. ET_o)[z]	B (40,92, 91,70% hist. ET_o)	C (40,85, 97,70% hist. ET_o)	D (80,80, 80, 80% ET_o)[y]
1) Real-time ET_o (mm)	226	226	226	226	505	505	505	505	521	521	521	521	219	219	219	219	1471	1471	1471	1471
2) Historical ET_o (mm)	228	228	228	228	440	440	440	440	550	550	550	550	221	221	221	221	1439	1439	1439	1439
3) ET_{crop} (ET_o x K_c month) (mm)	155	155	155	155	480	480	480	480	448	448	448	448	150	150	150	150	1233	1233	1233	1233
4) Rainfall (mm)	96	96	96	96	16	16	16	16	4	4	4	4	14	14	14	14	130	130	130	130
5) Historical rainfall (mm)[x]	141	141	141	141	34	34	34	34	8	8	8	8	82	82	82	82	265	265	265	265
6) Applied water (mm)[w]	191	92	99	160	358	413	367	381	447	503	544	447	177	154	162	159	1173	1162	1172	1147
7) Total water (rainfall plus applied) (mm)	287	188	195	256	374	429	383	397	451	507	548	451	191	168	176	173	1303	1292	1302	1277
8) (Applied water/ET_{crop}) x 100	123	59	64	103	75	86	76	79	100	112	121	100	118	103	108	106	95	94	95	93
9) (Applied water/real-time ET_o) x 100	85	41	44	71	71	82	73	75	86	97	104	86	81	70	74	73	80	79	80	78
10) (Applied water/historical ET_o) x 100	84	40	44	70	81	94	83	87	81	91	99	81	80	70	73	72	82	81	81	80
11) No. irrigation events	26	26	26	26	26	26	26	26	27	27	27	27	26	26	26	26	105	105	105	105
12) No. irrigation events canceled	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-dcumulative ET_o from an on-site CIMIS station approximately 169 ft from the center of the research plot.
[x]Anonymous. 1981. California summary, monthly total precipitation, 1949-1980. SDWR. 54 pp. plus microfiche.
[w]Applied water was calculated as (actual water time per day / system precipitation rate) x no. irrigation events. Numbers for each irrigation treatment were calculated as the average of three replicate plots.

Note: Within each column, underlined percentages can be compared to the percentages that are listed directly below the letters (A, B, C, D) that designate irrigation treatments.

Table 24. The effect of four irrigation treatment regimes and three 3-month periods in 1999 on the number of rating dates that tall fescue visual quality and color was ≥ 5.5.

	Irrigation treatment			
3-month period in 1999: Number rating dates	80, 80, 80, 80% historical ET_o Treatment A	40, 92, 91, 70% historical ET_o Treatment B	40, 85, 97, 70% historical ET_o Treatment C	80, 80, 80, 80% real-time ET_o Treatment D
January to March				
No. of rating dates	6	6	6	6
No. dates:				
Quality ≥ 5.5	0	0	0	0
Color ≥ 5.5	0	0	0	0
April to June				
No. of rating dates	6	6	6	6
No. dates:				
Quality ≥ 5.5	5	4	2	4
Color ≥ 5.5	5	4	2	4
July to September				
No. of rating dates	5	5	5	5
No. dates:				
Quality ≥ 5.5	0	1	2	0
Color ≥ 5.5	0	2	3	0
October to December				
No. of rating dates	5	5	5	5
No. dates:				
Quality ≥ 5.5	0	0	0	0
Color ≥ 5.5	0	0	1	1
1999 totals: January to December				
No. of rating dates	22	22	22	22
No. dates:				
Quality ≥ 5.5	5	5	4	4
Color ≥ 5.5	5	6	6	5

Table 25. The effect of four irrigation treatment regimes and three 3-month periods in 2000 on the number of rating dates that tall fescue visual quality and color was ≥ 5.5.

3-month period in 2000: Number rating dates	Irrigation treatment			
	80, 80, 80, 80% historical ET_o	40, 92, 91, 70% historical ET_o	40, 85, 97, 70% historical ET_o	80, 80, 80, 80% real-time ET_o
	Treatment A	Treatment B	Treatment C	Treatment D
January to March				
No. of rating dates	7	7	7	7
No. dates:				
Quality ≥ 5.5	4	3	3	5
Color ≥ 5.5	5	3	3	5
April to June				
No. of rating dates	6	6	6	6
No. dates:				
Quality ≥ 5.5	5	6	5	1
Color ≥ 5.5	6	6	6	5
July to September				
No. of rating dates	7	7	7	7
No. dates:				
Quality ≥ 5.5	1	3	2	0
Color ≥ 5.5	2	4	2	0
October to December				
No. of rating dates	5	5	5	5
No. dates:				
Quality ≥ 5.5	5	5	5	1
Color ≥ 5.5	5	5	5	5
2000 totals: April to December				
No. of rating dates	25	25	25	25
No. dates:				
Quality ≥ 5.5	15	17	15	7
Color ≥ 5.5	18	18	16	15

Table 26. The effect of irrigation level treatment on visual turfgrass quality of tall fescue in 1999 (1 to 9 scale, with 1=worst, 5=minimally acceptable, and 9=best tall fescue).

	Date																						
Irrigation treatments	8 Jan.	22 Jan.	5 Feb.	19 Feb.	5 Mar.	19 Mar.	2 Apr.	16 Apr.	14 May	28 May	11 June	25 June	23 July	6 Aug.	20 Aug.	3 Sept.	17 Sept.	15 Oct.	29 Oct.	12 Nov.	3 Dec.	17 Dec.	Over-all
80, 80, 80, 80% historical ET_o[z]	4.7	4.7	4.8	4.9	5.1	5.1	5.1	5.6	5.7	5.8	5.7	5.7	5.1	5.0	5.0	5.0	5.1	5.0	4.6	4.8	5.1	5.0	5.1
40, 92, 91, 70% historical ET_o	4.8	4.8	4.8	4.9	5.0	5.1	4.8	5.2	5.6	5.7	5.6	5.6	5.4	5.3	5.4	5.3	5.6	5.3	4.5	4.8	5.2	5.1	5.2
40, 85, 97, 70% historical ET_o	4.3	4.4	4.2	4.4	4.7	4.8	4.8	5.1	5.3	5.7	5.6	5.4	5.0	5.1	5.2	5.5	5.8	5.4	4.7	4.9	5.1	5.0	5.0
80, 80, 80, 80% $ET_{o\,(real\text{-}time)}$[y]	5.2	5.2	5.0	5.2	5.2	5.3	5.2	5.5	5.7	5.7	5.5	5.4	4.6	4.6	4.7	4.6	4.8	5.0	4.8	5.3	5.2	5.2	5.1
LSD, P=0.05	NS	NS	0.5	NS	0.3	0.3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]																							
Irrigation (I)	NS	NS	*	NS	*	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Date (D)																							***
I × D																							***

[z]Historical ET_o. Goldhamer, D. A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.
NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 27. The effect of irrigation level treatment on visual turfgrass color of tall fescue in 1999 (1 to 9 scale, with 1=brown, 5=minimally acceptable, and 9=darkest green tall fescue).

	Date																						
Irrigation treatments	8 Jan.	22 Jan.	5 Feb.	19 Feb.	5 Mar.	19 Mar.	2 Apr.	16 Apr.	14 May	28 May	11 June	25 June	23 July	6 Aug.	20 Aug.	3 Sept.	17 Sept.	15 Oct.	29 Oct.	12 Nov.	3 Dec.	17 Dec.	Over-all
80, 80, 80, 80% historical ET_o[z]	5..0	5.0	4.9	5.1	5.1	5.2	5.2	5.7	5.8	5.8	5.7	5.7	5.2	5.1	5.1	5.1	5.3	5.3	4.8	4.7	5.2	5.1	5.2
40, 92, 91, 70% historical ET_o	4.9	4.9	5.0	5.0	5.1	5.2	4.8	5.2	5.6	5.8	5.8	5.7	5.7	5.4	5.4	5.3	5.8	5.4	4.8	5.0	5.2	5.2	5.3
40, 85, 97, 70% historical ET_o	4.3	4.2	4.3	4.6	4.7	4.7	4.7	5.2	5.4	5.6	5.6	5.4	5.2	5.2	5.5	5.7	5.9	5.5	4.9	5.0	5.2	5.1	5.1
80, 80, 80, 80% $ET_{o\,(real\text{-}time)}$[y]	5.2	5.2	5.1	5.4	5.4	5.4	5.3	5.4	5.7	5.7	5.6	5.5	4.6	4.6	4.6	4.6	4.7	5.2	5.1	5.5	5.3	5.2	5.2
LSD, P=0.05	NS	0.6	0.5	NS	0.4	0.4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.9	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]																							
Irrigation (I)	NS	*	*	NS	*	*	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS
Date (D)																							***
I × D																							***

[z]Historical ET_o. Goldhamer, D. A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.
NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 28. The effect of irrigation level treatment on visual turfgrass quality of tall fescue in 2000 (1 to 9 scale, with 1=worst, 5=minimally acceptable, and 9=best tall fescue).

Irrigation treatments	Date																									
	7 Jan.	21 Jan.	4 Feb.	18 Feb.	3 Mar.	17 Mar.	31 Mar.	14 Apr.	28 Apr.	12 May	26 May	9 June	23 June	7 July	21 July	4 Aug.	18 Aug.	1 Sept.	22 Sept.	29 Sept.	13 Oct.	27 Oct.	17 Nov.	1 Dec.	15 Dec.	Over-all
80, 80, 80, 80% historical ET_o[z]	5.2	5.1	5.3	5.6	5.8	6.2	6.3	6.1	5.5	5.5	5.8	5.7	5.3	5.2	5.1	4.7	4.6	4.5	5.2	5.5	5.7	5.7	5.7	5.7	5.8	5.5
40, 92, 91, 70% historical ET_o	5.0	5.0	5.0	5.1	5.9	6.1	5.9	5.8	5.8	5.7	5.9	5.9	5.8	5.6	5.4	5.3	5.3	5.4	5.8	5.8	5.9	5.8	5.8	5.8	5.9	5.6
40, 85, 97, 70% historical ET_o	5.0	5.1	5.1	5.3	5.7	5.8	5.8	5.6	5.8	5.5	5.9	5.7	5.3	5.3	5.3	5.3	5.3	5.2	5.8	5.9	6.0	5.8	5.8	5.8	5.8	5.5
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	5.3	5.3	5.5	5.6	6.0	6.3	6.3	5.9	5.3	5.3	5.4	5.3	5.3	5.2	5.1	4.8	4.8	4.9	4.9	5.0	5.2	5.3	5.3	5.3	5.5	5.4
LSD, P=0.05	NS	NS	0.3	NS	NS	0.3	NS	NS	0.4	NS	NS	NS	NS	NS	NS	0.3	0.3	0.5	0.6	0.6	0.4	NS	NS	0.3	0.3	0.2
Summary of ANOVA effects[x]																										
Irrigation (I)	NS	NS	*	NS	NS	*	NS	NS	*	NS	NS	NS	NS	NS	NS	**	**	*	*	*	**	NS	NS	*	*	*
Date (D)																										***
I × D																										***

[z]Historical ET_o. Goldhamer, D. A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 29. The effect of irrigation level treatment on visual turfgrass color of tall fescue in 2000 (1 to 9 scale, with 1=brown, 5=minimally acceptable, and 9=darkest green tall fescue).

Irrigation treatments	Date																									
	7 Jan.	21 Jan.	4 Feb.	18 Feb.	3 Mar.	17 Mar.	31 Mar.	14 Apr.	28 Apr.	12 May	26 May	9 June	23 June	7 July	21 July	4 Aug.	18 Aug.	1 Sept.	22 Sept.	29 Sept.	13 Oct.	27 Oct.	17 Nov.	1 Dec.	15 Dec.	Over-all
80, 80, 80, 80% historical ET_o[z]	5.2	5.2	5.5	5.8	6.0	6.3	6.5	6.3	5.6	5.6	5.9	5.8	5.5	5.3	5.2	4.8	4.7	4.8	5.6	5.7	6.1	6.3	6.0	6.1	6.1	5.7
40, 92, 91, 70% historical ET_o	5.0	5.2	5.2	5.3	6.2	6.3	6.1	5.9	5.9	5.8	6.3	6.1	5.8	5.7	5.7	5.4	5.3	5.4	6.1	6.2	6.1	5.9	5.8	6.1	6.1	5.8
40, 85, 97, 70% historical ET_o	5.1	5.3	5.2	5.3	5.8	5.8	5.8	5.8	5.7	5.6	6.1	5.9	5.5	5.3	5.4	5.3	5.3	5.3	6.2	6.1	6.1	5.9	5.8	5.9	6.0	5.7
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	5.2	5.4	5.7	5.8	6.1	6.3	6.3	6.1	5.6	5.5	5.7	5.6	5.3	5.2	5.3	5.0	5.0	5.0	5.1	5.3	5.7	5.8	5.7	5.9	5.9	5.6
LSD, P=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.2	0.3	NS	0.5	0.5	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]																										
Irrigation (I)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	***	**	NS	**	**	NS	NS	NS	NS	NS	NS
Date (D)																										***
I × D																										***

[z]Historical ET_o. Goldhamer, D. A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 30. The effect of irrigation level treatment on percent leaves rolled and/or wilted in 1999.

	Date										
Irrigation treatments	22 Jan.	19 Feb.	19 Mar.	28 May	25 June	30 July	20 Aug.	24 Sep.	12 Nov.	17 Dec.	Overall
80, 80, 80, 80% historical ET_o[z]	40	0	0	0	12	35	38	8	43	27	20
40, 92, 91, 70% historical ET_o	43	0	5	0	1	22	27	1	37	42	18
40, 85, 97, 70% historical ET_o	47	0	10	0	20	25	25	5	30	28	19
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	17	0	0	0	33	57	63	33	25	38	27
LSD, P=0.05	22	.	NS	.	14	NS	NS	15	NS	NS	NS
Summary of ANOVA effects[x]											
Irrigation (I)	*	.	NS	.	**	NS	NS	**	NS	NS	NS
Date (D)											***
I × D											***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 31. The effect of irrigation level treatment on percent brown leaves in 1999.

Irrigation treatments	Date										Overall
	22 Jan.	19 Feb.	19 Mar.	28 May	25 June	30 July	20 Aug.	24 Sep.	12 Nov.	17 Dec.	
80, 80, 80, 80% historical ET_o[z]	30	0	0	0	4	14	15	1	18	7	9
40, 92, 91, 70% historical ET_o	33	0	0	0	1	8	14	0	17	18	9
40, 85, 97, 70% historical ET_o	47	0	3	0	5	10	11	1	13	12	10
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	27	0	0	0	13	30	35	18	3	10	14
LSD, P=0.05	NS	.	NS	.	8	NS	NS	5	NS	NS	NS
Summary of ANOVA effects[x]											
Irrigation (I)	NS	.	NS	.	*	NS	NS	***	NS	NS	NS
Date (D)											***
I × D											***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \leq$ 0.05, 0.01, 0.001, respectively.

Table 32. The effect of irrigation level treatment on percent leaves rolled and/or wilted in 2000.

	Date										
Irrigation treatments	21 Jan.	25 Feb.	17 Mar.	12 May	2 June	23 June	21 July	1 Sept.	29 Sept.	27 Oct.	Overall
80, 80, 80, 80% historical ET_o[z]	10	0	0	7	28	57	68	5	0	0	18
40, 92, 91, 70% historical ET_o	17	0	0	0	22	30	30	0	0	0	10
40, 85, 97, 70% historical ET_o	13	0	3	2	32	57	32	1	0	0	14
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	12	0	0	10	45	58	53	5	0	0	20
LSD, P=0.05	NS	NS	NS	10	NS	NS	30	NS	NS	NS	NS
Summary of ANOVA effects[x]											
Irrigation (I)	NS	NS	NS	*	NS	NS	*	NS	NS	NS	NS
Date (D)											***
I × D											**

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P\leq$ 0.05, 0.01, 0.001, respectively.

Table 33. The effect of irrigation level treatment on percent brown leaves in 2000.

	Date										
Irrigation treatments	21 Jan.	25 Feb.	17 Mar.	12 May	2 June	23 June	21 July	1 Sept.	29 Sept.	27 Oct.	Overall
80, 80, 80, 80% historical ET_o[z]	0	0	0	15	17	35	35	15	10	6	12
40, 92, 91, 70% historical ET_o	5	0	0	3	8	17	17	8	4	2	6
40, 85, 97, 70% historical ET_o	2	0	0	7	13	32	15	8	3	1	8
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	0	0	0	30	22	30	30	12	15	12	13
LSD, P=0.05	NS	NS	NS	NS	NS	NS	12	NS	5	6	5
Summary of ANOVA effects[x]											
Irrigation (I)	NS	NS	NS	NS	NS	NS	*	NS	**	**	*
Date (D)											***
I × D											**

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 34. The effect of irrigation level treatment on clipping yield[z] in 1999.

Irrigation treatment	Date				1999 cumulative yield
	2 Apr.	11 June	10 Sept.	12 Nov.	
80, 80, 80, 80% historical ET_o[y]	5.7	18.5	26.7	16.7	67.7
40, 92, 91, 70% historical ET_o	2.6	17.5	31.4	15.5	66.9
40, 85, 97, 70% historical ET_o	3.1	14.7	30.9	13.7	62.4
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[x]	8.0	23.2	24.0	15.2	70.4
LSD, P=0.05	3.4	NS	NS	NS	NS
Summary of ANOVA effects[w]					
Irrigation	*	NS	NS	NS	NS

[z]Clipping yield measured as g/33.3 ft^2 of dry clippings per 7 d growth.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical design effects by date.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 35. The effect of irrigation level treatment on clipping yield[z] in 2000.

Irrigation treatment	Date				2000 cumulative yield
	31 Mar.	9 June	1 Sept.	10 Nov.	
80, 80, 80, 80% historical ET_o[y]	30.4	20.3	17.3	24.3	92.3
40, 92, 91, 70% historical ET_o	18.7	22.5	25.2	25.1	91.4
40, 85, 97, 70% historical ET_o	20.0	16.0	27.2	27.5	90.6
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[x]	33.1	16.3	26.5	25.2	101.1
LSD, P=0.05	NS	NS	6.9	NS	NS
Summary of ANOVA effects[w]					
Irrigation	NS	NS	*	NS	NS

[z]Clipping yield measured as g/33.3 ft^2 of dry clippings per 7 d growth.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical design effects by date.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 36. The effect of irrigation level treatment on clipping water content[z] in 1999.

Irrigation treatments	Date: 2 Apr.	11 June	10 Sept.	12 Nov.	1999 overall
80, 80, 80, 80% historical ET_o[y]	2.3	2.2	2.2	1.9	2.1
40, 92, 91, 70% historical ET_o	2.3	2.3	2.4	1.9	2.2
40, 85, 97, 70% historical ET_o	2.5	2.2	2.4	1.8	2.2
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[x]	2.3	2.4	2.0	2.0	2.2
LSD, P=0.05	NS	NS	NS	NS	NS
Summary of ANOVA effects[w]					
Irrigation (I)	NS	NS	NS	NS	NS
Date (D)					**
I × D					NS

[z]Clipping water content calculated as: (fresh wt-dry wt)/dry wt.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical design effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 37. The effect of irrigation level treatment on clipping water content[z] in 2000.

Irrigation level treatments	Date: 31 Mar.	9 June	1 Sept.	10 Nov.	2000 overall
80, 80, 80, 80% historical ET_o[y]	2.23	1.85	2.12	2.95	2.29
40, 92, 91, 70% historical ET_o	1.95	1.95	2.54	3.09	2.38
40, 85, 97, 70% historical ET_o	1.98	1.71	2.50	2.92	2.28
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[x]	2.19	1.78	2.47	2.92	2.34
LSD, P=0.05	0.19	NS	0.23	NS	NS
Summary of ANOVA effects[w]					
Irrigation (I)	*	NS	*	NS	NS
Date (D)					***
I × D					**

[z]Clipping water content calculated as: (fresh wt-dry wt)/dry wt.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical design effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 38. Tall fescue relative leaf water content[z] for four irrigation treatments in 1999.

Irrigation treatments	Date					1999 overall
	23 Feb.	20 Apr.	15 June	31 Aug.	23 Nov.	
80, 80, 80, 80% historical ET_o[y]	95.88	94.80	91.32	89.02	96.56	93.51
40, 92, 91, 70% historical ET_o	96.09	95.51	92.37	90.72	96.40	94.22
40, 85, 97, 70% historical ET_o	94.29	93.86	92.46	93.81	96.12	94.11
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[x]	96.00	95.66	91.90	83.56	96.64	92.75
LSD, P=0.05	1.33	NS	NS	NS	NS	NS
Summary of ANOVA effects[w]						
Irrigation (I)	*	NS	NS	NS	NS	NS
Date (D)						***
I × D						*

[z]Relative leaf water content calculated as: [(fresh wt−dry wt)/(rehydrated wt−dry wt)]×100.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical design effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P\leq$ 0.05, 0.01, 0.001, respectively.

Table 39. Tall fescue relative leaf water content[z] for four irrigation treatments in 2000.

Irrigation level treatment	Date					2000 overall
	22 Feb.	25 Apr.	13 June	5 Sept.	21 Nov.	
80, 80, 80, 80% historical ET_o[y]	98.71	94.77	81.93	91.12	87.82	90.87
40, 92, 91, 70% historical ET_o	98.80	97.00	91.86	93.55	92.76	94.51
40, 85, 97, 70% historical ET_o	99.06	93.39	83.32	92.40	91.37	91.91
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[x]	98.79	93.57	85.35	90.67	91.96	92.07
LSD, P=0.05	NS	1.91	NS	NS	NS	1.49
Summary of ANOVA effects[w]						
Irrigation (I)	NS	**	NS	NS	NS	**
Date (D)						***
I × D						NS

[z]Relative leaf water content calculated as: [(fresh wt−dry wt)/(rehydrated wt−dry wt)]×100.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical design effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P\leq$ 0.05, 0.01, 0.001, respectively.

Table 40. Tall fescue leaf water content[z] for four irrigation treatments in 1999.

Irrigation treatments	Date					
	23 Feb.	20 Apr.	15 June	31 Aug.	23 Nov.	1999 overall
80, 80, 80, 80% hist. ET_o[y]	2.68	2.98	2.85	2.65	2.93	2.82
40, 92, 91, 70% hist. ET_o	2.52	2.76	3.04	2.85	3.02	2.84
40, 85, 97, 70% hist. ET_o	2.47	2.64	2.89	3.01	2.79	2.76
80, 80, 80, 80% ET_o[x]	2.83	3.20	2.74	2.29	3.16	2.84
LSD, *P*=0.05	NS	0.27	NS	NS	NS	NS
Summary of ANOVA effects[w]						
Irrigation (I)	NS	**	NS	NS	NS	NS
Date (D)						***
I × D						***

[z]Leaf water content calculated as: (fresh-dry)/dry.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical design effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P \leq$ 0.05, 0.01, 0.001, respectively.

Table 41. Tall fescue leaf water content[z] for four irrigation treatments in 2000.

Irrigation level treatment	Date					
	22 Feb.	25 Apr.	13 June	5 Sept.	21 Nov.	2000 overall
80, 80, 80, 80% hist. ET_o[y]	3.82	3.39	2.58	3.10	2.95	3.17
40, 92, 91, 70% hist. ET_o	3.54	3.30	3.13	3.35	3.22	3.31
40, 85, 97, 70% hist. ET_o	3.48	3.17	2.46	3.23	3.08	3.08
80, 80, 80, 80% ET_o[x]	3.79	3.22	2.58	3.26	3.31	3.22
LSD, *P*=0.05	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[w]						
Irrigation (I)	NS	NS	NS	NS	NS	NS
Date (D)						***
I × D						*

[z]Leaf water content calculated as: (fresh-dry)/dry×100.
[y]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[x]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[w]Randomized complete block statistical design effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P \leq$ 0.05, 0.01, 0.001, respectively.

Table 42. The effect of irrigation level treatment on soil water tension as measured with Watermark granular matrix sensors at the 6-inch depth in 1999.

	Date												
	19 Jan.	23 Feb.	30 Mar.	20 Apr.	18 May	22 June	27 July	24 Aug.	21 Sept.	19 Oct.	23 Nov.	14 Dec.	Overall
Irrigation treatments	*KPa*												
80, 80, 80, 80% historical ET_o[z]	44	10	10	13	15	22	41	39	13	56	53	61	31
40, 92, 91, 70% historical ET_o	144	16	70	16	14	19	31	43	18	64	92	107	53
40, 85, 97, 70% historical ET_o	133	17	67	15	13	21	21	15	11	40	48	47	37
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	53	10	11	18	31	54	64	86	63	90	72	86	53
LSD, P=0.05	49	6	11	NS	8	23	NS	NS	15	NS	NS	NS	NS
Summary of ANOVA effects[x]													
Irrigation (I)	**	*	***	NS	**	*	NS	NS	***	NS	NS	NS	NS
Date (D)													***
I × D													***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p. 62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 51 m (169 ft) from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 43. The effect of irrigation level treatment on soil water tension as measured with Watermark granular matrix sensors at the 12-inch depth in 1999.

	Date												
	19 Jan.	23 Feb.	30 Mar.	20 Apr.	18 May	22 June	27 July	24 Aug.	21 Sept.	19 Oct.	23 Nov.	14 Dec.	Overall
Irrigation treatments	------------ *KPa* ------------												
80, 80, 80, 80% historical ET_o[z]	81	5	6	7	11	21	40	58	44	45	85	85	41
40, 92, 91, 70% historical ET_o	104	27	46	9	9	17	36	43	8	42	96	90	44
40, 85, 97, 70% historical ET_o	120	46	66	8	8	13	19	19	6	45	98	108	44
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	51	6	5	12	24	47	46	89	75	66	81	91	49
LSD, *P*=0.05	NS	NS	33	NS	8	20	NS	NS	54	NS	NS	NS	NS
Summary of ANOVA effects[x]													
Irrigation (I)	NS	NS	**	NS	**	*	NS	NS	*	NS	NS	NS	NS
Date (D)													***
I × D													**

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p. 62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 51 m (169 ft) from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 44. The effect of irrigation level treatment on soil water tension as measured with Watermark granular matrix sensors at the 6-inch depth in 2000.

	Date													
	18 Jan.	22 Feb.	7 Mar.	21 Mar.	25 Apr.	16 May	13 June	18 July	29 Aug.	19 Sept.	17 Oct.	21 Nov.	19 Dec.	Overall
Irrigation treatments	---------- *KPa* ----------													
80, 80, 80, 80% historical ET_o[z]	11	8	7	15	12	23	54	58	65	59	17	37	32	31
40, 92, 91, 70% historical ET_o	102	22	9	21	16	23	30	34	34	20	15	37	35	29
40, 85, 97, 70% historical ET_o	55	9	8	19	14	26	51	38	35	17	14	29	19	26
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	69	10	10	14	22	44	54	53	57	52	27	26	35	36
LSD, P=0.05	NS	NS	NS	NS	NS	16	NS	NS	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]														
Irrigation (I)	NS	NS	NS	NS	NS	*	NS	NS	NS	NS	NS	NS	NS	NS
Date (D)														***
I × D														**

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p. 62).
[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 51 m (169 ft) from the center of the research plot.
[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 45. The effect of irrigation level treatment on soil water tension as measured with Watermark granular matrix sensors at the 12-inch depth in 2000.

	Date													
	18 Jan.	22 Feb.	7 Mar.	21 Mar.	25 Apr.	16 May	13 June	18 July	29 Aug.	19 Sept.	17 Oct.	21 Nov.	19 Dec.	Overall
Irrigation treatments	*KPa*													
80, 80, 80, 80% historical ET_o [z]	48	3	3	10	9	30	53	104	114	94	32	76	79	50
40, 92, 91, 70% historical ET_o	65	15	4	12	11	19	35	52	70	19	11	18	22	27
40, 85, 97, 70% historical ET_o	91	24	5	12	16	32	77	70	89	48	13	16	22	40
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$ [y]	66	5	5	10	25	47	57	51	58	87	58	43	42	43
LSD, P=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects [x]														
Irrigation (I)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Date (D)														***
I × D														***

[z] Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p. 62).

[y] Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 51 m (169 ft) from the center of the research plot.

[x] Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

NS, *, **, *** Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 46. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 9-inch depth in 1999.

	Date												
	19 Jan.	23 Feb.	30 Mar.	20 Apr.	18 May	22 June	27 July	24 Aug.	21 Sept.	19 Oct.	23 Nov.	14 Dec.	Overall
Irrigation treatments	---------- *cm^3 H_2O $\cdot cm^{-3}$ soil x 100* ----------												
80, 80, 80, 80% historical ET_o[z]	9.1	17.6	17.6	16.8	16.3	14.6	9.3	9.7	14.7	6.3	8.6	7.3	12.3
40, 92, 91, 70% historical ET_o	7.2	15.7	12.9	16.0	16.7	15.3	11.6	11.3	16.8	8.2	7.4	6.4	12.1
40, 85, 97, 70% historical ET_o	7.6	16.4	12.5	17.3	17.6	16.0	14.7	15.5	18.2	9.3	10.1	9.3	13.7
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	13.2	18.8	12.7	17.3	13.1	11.6	7.9	7.3	9.9	8.1	11.5	7.9	11.6
LSD, *P*=0.05	NS	1.8	NS	NS	1.1	2.4	4.7	4.8	3.7	NS	NS	NS	NS
Summary of ANOVA effects[x]													
Irrigation (I)	NS	*	NS	NS	***	*	*	*	**	NS	NS	NS	NS
Date (D)													***
I × D													***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \le 0.05, 0.01, 0.001$, respectively.

Table 47. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 12-inch depth in 1999.

	Date												
	19 Jan.	23 Feb.	30 Mar.	20 Apr.	18 May	22 June	27 July	24 Aug.	21 Sept.	19 Oct.	23 Nov.	14 Dec.	Overall
Irrigation treatments	*cm^3 H_2O/cm^3 soil x 100*												
80, 80, 80, 80% historical ET_o[z]	9.4	18.6	21.3	18.8	17.3	15.8	10.5	10.4	14.6	8.1	9.0	8.6	13.5
40, 92, 91, 70% historical ET_o	9.3	15.8	14.2	17.7	18.4	17.1	13.1	12.7	17.4	10.7	8.8	8.4	13.6
40, 85, 97, 70% historical ET_o	9.5	16.5	9.6	18.7	19.1	17.7	16.3	16.8	19.3	12.0	11.5	10.8	14.8
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	9.4	19.8	9.6	19.0	15.3	13.2	9.5	9.0	10.9	10.1	11.5	9.7	12.6
LSD, P=0.05	NS	2.4	8.7	NS	1.9	2.1	NS	5.5	4.2	NS	NS	NS	NS
Summary of ANOVA effects[x]													
Irrigation (I)	NS	*	*	NS	**	**	NS	*	**	NS	NS	NS	NS
Date (D)													***
I × D													***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 48. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 18-inch depth in 1999.

	Date												
	19 Jan.	23 Feb.	30 Mar.	20 Apr.	18 May	22 June	27 July	24 Aug.	21 Sept.	19 Oct.	23 Nov.	14 Dec.	Overall
Irrigation treatments	---------- *cm^3 H_2O/cm^3 soil x 100* ----------												
80, 80, 80, 80% historical ET_o[z]	12.0	21.2	20.6	21.0	19.9	18.4	12.8	12.3	14.5	11.6	11.0	10.9	15.5
40, 92, 91, 70% historical ET_o	12.7	15.8	17.7	19.5	19.9	19.5	15.4	14.9	17.3	14.8	11.9	11.3	15.9
40, 85, 97, 70% historical ET_o	11.9	14.1	16.6	19.9	20.5	19.9	17.5	18.5	20.2	16.0	14.1	13.4	16.9
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	16.0	21.2	15.5	21.0	17.9	15.7	12.2	11.5	12.3	12.4	12.6	11.9	15.0
LSD, *P*=0.05	NS	2.4	NS	NS	NS	NS	NS	NS	5.3	NS	NS	NS	NS
Summary of ANOVA effects[x]													
Irrigation (I)	NS	***	NS	NS	NS	NS	NS	NS	*	NS	NS	NS	NS
Date (D)													***
I × D													***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 49. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 24-inch depth in 1999.

	Date												
	19 Jan.	23 Feb.	30 Mar.	20 Apr.	18 May	22 June	27 July	24 Aug.	21 Sept.	19 Oct.	23 Nov.	14 Dec.	Overall
Irrigation treatments	------------- *cm^3 H_2O/cm^3 soil x 100* -------------												
80, 80, 80, 80% historical ET_o[z]	11.9	20.1	19.7	20.4	19.2	18.5	13.8	12.4	13.2	11.7	10.8	10.6	15.2
40, 92, 91, 70% historical ET_o	14.0	15.2	17.7	18.8	19.4	19.4	15.8	14.6	15.5	15.0	12.7	12.0	15.9
40, 85, 97, 70% historical ET_o	12.5	13.3	15.8	18.5	19.5	19.6	17.5	17.9	19.7	17.2	15.4	14.5	16.8
80, 80, 80, 80% $ET_{o\ (real-time)}$[y]	15.4	18.9	15.6	20.1	13.5	16.3	12.1	11.0	11.4	11.7	11.9	11.2	14.1
LSD, P=0.05	NS	3.0	NS	NS	NS	NS	3.8	NS	4.6	NS	NS	NS	NS
Summary of ANOVA effects[x]													
Irrigation (I)	NS	**	NS	NS	NS	NS	*	NS	*	NS	NS	NS	NS
Date (D)													***
I × D													***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 50. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 36-inch depth in 1999.

	Date												
	19 Jan.	23 Feb.	30 Mar.	20 Apr.	18 May	22 June	27 July	24 Aug.	21 Sept.	19 Oct.	23 Nov.	14 Dec.	Overall
Irrigation treatments	------------ *cm^3 H_2O/cm^3 soil x 100* ------------												
80, 80, 80, 80% historical ET_o[z]	10.0	13.9	14.0	15.3	14.3	13.7	12.1	10.5	10.4	10.2	10.0	9.6	12.0
40, 92, 91, 70% historical ET_o	10.2	10.3	12.0	12.5	12.7	13.4	11.4	10.6	11.4	10.8	9.9	9.5	11.2
40, 85, 97, 70% historical ET_o	12.9	12.8	12.9	13.5	15.1	15.8	15.2	14.9	16.1	15.2	9.5	13.6	13.9
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	10.5	12.7	12.3	14.7	13.5	12.4	10.4	9.0	8.6	8.8	8.6	8.1	10.8
LSD, *P*=0.05	NS	NS	NS	NS	NS	NS	2.6	3.5	3.9	3.4	NS	3.2	2.0
Summary of ANOVA effects[x]													
Irrigation (I)	NS	NS	NS	NS	NS	NS	*	*	*	*	NS	*	*
Date (D)													***
I × D													**

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 51. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 48-inch depth in 1999.

	Date												
	19 Jan.	23 Feb.	30 Mar.	20 Apr.	18 May	22 June	27 July	24 Aug.	21 Sept.	19 Oct.	23 Nov.	14 Dec.	Overall
Irrigation treatments	---------- *cm^3 H_2O/cm^3 soil x 100* ----------												
80, 80, 80, 80% historical ET_o[z]	11.3	12.2	15.6	15.3	14.4	13.8	13.0	12.1	11.9	11.7	11.7	11.3	12.8
40, 92, 91, 70% historical ET_o	10.0	10.2	13.5	12.0	12.6	12.9	11.6	10.8	11.1	11.2	10.5	10.1	11.4
40, 85, 97, 70% historical ET_o	12.5	12.2	12.5	12.5	14.1	14.7	14.1	13.9	15.6	14.6	13.7	12.8	13.6
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	12.3	13.7	11.6	15.5	14.8	14.2	13.5	12.2	11.9	11.8	11.6	11.5	12.9
LSD, P=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]													
Irrigation (I)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Date (D)													***
I × D													**

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 52. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 9-inch depth in 2000.

	Date													
	18 Jan.	22 Feb.	10 Mar.	21 Mar.	25Apr.	16 May	13 June	18 July	29 Aug.	19 Sept.	17 Oct.	21 Nov.	19 Dec.	Overall
Irrigation treatments	--- *cm^3 H_2O/cm^3 soil x 100* ---													
80, 80, 80, 80% historical ET_o[z]	14.4 a	18.6	22.7	18.6 a	20.3	12.1	7.5	6.4	7.6 b	9.0 b	13.3 bc	11.6	14.9	13.6
40, 92, 91, 70% historical ET_o	6.9 c	18.3	22.4	15.6 a	19.4	13.6	10.1	9.2	10.7 ab	13.7 a	15.2 ab	11.5	12.9	13.8
40, 85, 97, 70% historical ET_o	10.8 ab	19.6	23.4	17.9 a	20.7	13.1	9.2	10.4	12.8 a	15.7 a	16.8 a	14.1	15.7	15.4
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	10.2 bc	18.8	22.7	18.9 a	18.2	10.2	7.2	7.8	11.6 a	9.0 b	11.7 c	12.5	13.0	13.2
LSD, *P*=0.05	3.8	NS	NS	2.3	NS	NS	NS	NS	3.7	3.0	1.9	NS	NS	NS
Summary of ANOVA effects[x]														
Irrigation (I)	*	NS	NS	*	NS	NS	NS	NS	*	**	**	NS	NS	NS
Date (D)														***
I × D														***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 53. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 12-inch depth in 2000.

	Date													
	18 Jan.	22 Feb.	10 Mar.	21 Mar.	25Apr.	16 May	13 June	18 July	29 Aug.	19 Sept.	17 Oct.	21 Nov.	19 Dec.	Overall
Irrigation treatments	-- *cm^3 H_2O/cm^3 soil x 100* --													
80, 80, 80, 80% historical ET_o[z]	13.6 a	19.0	23.1	20.5	20.3	12.8	8.9	8.0	8.3	9.8 c	12.6 b	12.0	14.1	14.1
40, 92, 91, 70% historical ET_o	8.6 c	18.5	23.2	19.5	20.0	14.8	11.9	10.8	11.4	14.4 b	16.4 a	13.6	13.7	15.1
40, 85, 97, 70% historical ET_o	11.7 ab	19.9	24.2	21.2	21.1	14.7	10.9	12.0	13.0	17.2 a	18.4 a	15.9	16.7	16.7
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	10.6 bc	19.4	23.7	21.4	18.6	11.6	9.3	9.6	12.5	10.7 c	12.3 b	12.8	13.4	14.3
LSD, P=0.05	2.5	NS	NS	NS	NS	NS	NS	NS	NS	2.6	2.3	NS	NS	NS
Summary of ANOVA effects[x]														
Irrigation (I)	**	NS	NS	NS	NS	NS	NS	NS	NS	***	***	NS	NS	NS
Date (D)														***
I × D														***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 54. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 18-inch depth in 2000.

	Date													
	18 Jan.	22 Feb.	10 Mar.	21 Mar.	25Apr.	16 May	13 June	18 July	29 Aug.	19 Sept.	17 Oct.	21 Nov.	19 Dec.	Overall
Irrigation treatments	*cm^3 H_2O/cm^3 soil x 100*													
80, 80, 80, 80% historical ET_o[z]	13.2	20.5 a	24.5	23.2	21.8	16.0	13.0	10.7	9.9	11.0	11.0 b	11.0 b	12.0 b	15.2
40, 92, 91, 70% historical ET_o	11.3	12.6 b	24.0	22.6	21.6	17.2	15.5	13.2	12.5	13.7	17.0 a	16.1 a	16.2 a	16.5
40, 85, 97, 70% historical ET_o	13.2	15.8 b	25.4	24.1	22.1	17.2	14.4	14.0	14.5	15.8	18.8 a	18.2 a	18.1 a	18.0
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	11.9	16.4 b	24.5	23.2	21.0	14.5	12.6	11.4	12.8	12.0	12.0 b	12.1 b	12.5 b	15.1
LSD, P=0.05	NS	4.1	NS	NS	NS	NS	NS	NS	NS	NS	3.0	2.7	3.5	NS
Summary of ANOVA effects[x]														
Irrigation (I)	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	**	**	**	NS
Date (D)														***
I × D														***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 55. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 24-inch depth in 2000.

	Date													
	18 Jan.	22 Feb.	10 Mar.	21 Mar.	25 Apr.	16 May	13 June	18 July	29 Aug.	19 Sept.	17 Oct.	21 Nov.	19 Dec.	Overall
Irrigation treatments	---------- *cm^3 H_2O/cm^3 soil x 100* ----------													
80, 80, 80, 80% historical ET_o[z]	11.8	20.5 a	24.5	23.2	21.8	17.1	13.0	10.7	9.9	11.0	11.0 b	11.0 b	12.0 b	15.2
40, 92, 91, 70% historical ET_o	11.7	12.6 b	24.0	22.6	21.6	17.5	15.5	13.2	12.5	13.7	17.0 a	16.1 a	16.2 a	16.5
40, 85, 97, 70% historical ET_o	13.9	15.8 b	25.4	24.1	22.1	17.8	14.4	14.0	14.5	15.8	18.8 a	18.2 a	18.1 a	18.0
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	11.25	16.4 b	24.5	23.2	21.0	14.8	12.6	11.4	12.8	12.0	12.0 b	12.1 b	12.5 b	15.1
LSD, P=0.05	NS	4.1	NS	NS	NS	NS	NS	NS	NS	NS	3.0	2.7	3.5	NS
Summary of ANOVA effects[x]														
Irrigation (I)	NS	*	NS	NS	NS	NS	NS	NS	NS	NS	**	**	**	NS
Date (D)														***
I × D														***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05, 0.01, 0.001$, respectively.

Table 56. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 36-inch depth in 2000.

	Date													
	18 Jan.	22 Feb.	10 Mar.	21 Mar.	25 Apr.	16 May	13 June	18 July	29 Aug.	19 Sept.	17 Oct.	21 Nov.	19 Dec.	Overall
Irrigation treatments	---------- *cm^3 H_2O/cm^3 soil x 100* ----------													
80, 80, 80, 80% historical ET_o[z]	9.9 b	15.0 a	19.3	18.0 b	16.9 b	13.0 b	11.5 b	9.5 b	8.3	8.4	8.6	9.0 b	9.3 b	12.0 b
40, 92, 91, 70% historical ET_o	9.4 b	9.2 b	16.2	15.9 c	14.4 c	11.2 c	10.8 b	10.1 b	9.4	9.9	10.6	10.1 b	10.3 b	11.3 b
40, 85, 97, 70% historical ET_o	12.9 b	13.4 a	20.5	20.2 a	18.7 a	15.1 a	14.0 a	12.9 a	12.8	13.2	14.5	14.1 a	14.5 a	15.1 a
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	8.2 b	9.5 b	18.2	17.0 bc	15.8 bc	11.7 bc	10.5 b	9.2 b	7.8	8.5	8.4	8.5 b	8.7 b	10.9 b
LSD, P=0.05	2.9	2.3	NS	2.1	1.8	1.5	2.2	1.7	3.6	2.3	2.2	2.0	2.2	1.7
Summary of ANOVA effects[x]														
Irrigation (I)	*	**	NS	**	**	**	*	**	*	**	**	**	**	**
Date (D)														***
I × D														***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).

[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.

[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.

NS, *, **, ***Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 57. The effect of irrigation level treatment on volumetric soil water content as measured with a neutron probe at the 48-inch depth in 2000.

	Date													
	18 Jan.	22 Feb.	10 Mar.	21 Mar.	25 Apr.	16 May	13 June	18 July	29 Aug.	19 Sept.	17 Oct.	21 Nov.	19 Dec.	Overall
Irrigation treatments	*cm^3 H_2O/cm^3 soil x 100*													
80, 80, 80, 80% historical ET_o[z]	11.2	13.3	19.5	18.0	17.0	13.1	12.6	11.9	11.2	11.0	11.2	11.2	11.3	13.3
40, 92, 91, 70% historical ET_o	9.9	9.7	14.8	15.6	14.2	11.2	10.7	10.3	9.7	10.1	10.6	10.3	10.4	11.3
40, 85, 97, 70% historical ET_o	12.5	12.8	18.2	18.6	17.3	13.6	13.1	12.7	12.8	13.3	13.7	13.2	13.4	14.3
80, 80, 80, 80% $ET_{o\ (real\text{-}time)}$[y]	11.2	11.1	17.1	17.9	16.9	13.3	12.7	12.1	11.8	11.7	11.5	11.4	11.4	13.1
LSD, P=0.05	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Summary of ANOVA effects[x]														
Irrigation (I)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Date (D)														***
I × D														***

[z]Historical ET_o. Goldhamer, D.A. and R.L. Snyder. 1989. Irrigation scheduling: A guide for efficient on-farm water management. Univ. of California, Division of Agricultural and Natural Resources. Publ. 21454 (see p.62).
[y]Real-time ET_o based on 7-d accumulative ET_o from an on-site CIMIS station 169 ft from the center of the research plot.
[x]Randomized complete block design statistical effects by date and overall ANOVA via repeated measures design.
[NS, *, **, ***]Nonsignificant or significant at $P \leq 0.05$, 0.01, 0.001, respectively.

Table 58. The effect of four irrigation treatment regimes and 3-month periods on the number of rating dates that tall fescue visual quality and color was ≥ 5.5.

3-month period (1998 to 2000 average) Number rating dates	Irrigation treatment			
	80, 80, 80, 80% historical ET_o Treatment A	40, 92, 91, 70% historical ET_o Treatment B	40, 85, 97, 70% historical ET_o Treatment C	80, 80, 80, 80% real-time ET_o Treatment D
January to March				
No. of rating dates	13	13	13	13
No. dates:				
Quality ≥ 5.5	4	3	3	5
Color ≥ 5.5	5	3	3	5
April to June				
No. of rating dates	19	19	19	19
No. dates:				
Quality ≥ 5.5	17	17	14	12
Color ≥ 5.5	18	17	15	16
July to September				
No. of rating dates	19	19	19	19
No. dates:				
Quality ≥ 5.5	3	11	11	6
Color ≥ 5.5	7	13	12	7
October to December				
No. of rating dates	16	16	16	16
No. dates:				
Quality ≥ 5.5	7	9	6	7
Color ≥ 5.5	10	10	7	12
3-yr totals: January to December				
No. of rating dates	67	67	67	67
No. dates:				
Quality ≥ 5.5	31	40	34	30
Color ≥ 5.5	40	43	37	30