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WATER CONSERVATION WITH URBAN LANDSCAPE PLANTS

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ABSTRACT

Water shortages are a common problem in much of the southwest. Increasing urbanization and increasing population places greater demands on dwindling water supplies. Over half of the water used in urban areas of the southwest is used in the irrigation of landscapes. To help cope with increased urban water demands and low water supplies, research was conducted from March 1981 to July 1983 at The Texas Agricultural Experiment Station at Dallas to gain information relative to consumptive water use by native and non-native landscape plants.

Twenty weighing lysimeters were constructed and installed and plants established in the lysimeters and adjacent areas. The lysimeters were made from 0.6 X 0.9 m undisturbed cores of Austin silty clay soil. Plants used in the lysimeter study were buffalograss, St. Augustinegrass, cenizo, boxwood and Texas barberry. All plants are native to Texas except boxwood and St. Augustinegrass. Four lysimeters were planted to each plant type. This allowed two moisture levels and two replications of each plant type.

There was no difference in water use by St. Augustinegrass and buffalograss during the year of establishment. Daily water use ranged from 0.49 to 0.08 cm per day but was generally 50% class A pan evaporation. St. Augustinegrass used 0.03 cm/day more water than buffalograss during 1982. Irrigation treatments used in 1982 did not influence water use by either grass type but buffalograss retained higher quality under dry treatment (irrigated at 0.40 bar moisture tension) than St. Augustinegrass. Water use from May to July 1983 was

highest (of all treatments) by St. Augustinegrass when irrigated at 0.25 bar soil moisture tension at 76 cm depth and lowest (of all treatments) by buffalograss when irrigated at 0.75 bar soil moisture tension at 76 cm depth.

Application of 50% class A pan evaporation each week appears to be an acceptable guideline for irrigation of either turfgrass but research should be conducted over a longer time period to obtain more specific guidelines for each grass species.

Water use by shrubs in lysimeters was variable and not influenced by plant type during the period of establishment (Fall 1981). During 1982 water use was influenced more by plant size than by specie or water level. Cenizo had much faster growth rate than the other shrubs in the study.

Water use by container grown plants indicated that cenizo had higher water use efficiency than boxwood or Indian Hawthorn. Water use was determined for several native shrubs and of the ones compared, Texas barberry appeared to have the most promise for use in water conserving landscapes.

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INTRODUCTION

Maintenance and beautification of landscapes accounts for 50% or more of the water used by urban areas of the Southwestern United States. Increasing urbanization and increasing population places greater demands on dwindling water supplies. Urban water needs for Texas are estimated to be 50% greater in the year 2000 than in 1980. Water for use in landscapes is in short supply, particularly during dry periods such as the summer of 1980, when many landscapes were lost due to lack of water. Native plants from arid areas normally survive without supplemental irrigation. Use of native plants in urban landscapes could reduce urban water requirements, however, exact comsumptive water use by native plants in landscapes or nursery situations is not known. Research was conducted to investigate and compare water requirements of several native shrubs and a turfgrass to non-native shrubs and turfgrass now in use.

Background Information and Related Research

Increasing urbanization, particularly in the arid southwestern states has placed new demands on urban water systems. Estimated water use by urban areas in Texas in 1980 was 3,359.8 thousand acre feet and the projected needs for the year 2000 are 5,038.4 thousand acre feet (1). This represents a 50% increase in urban water needs in a relatively short time. Water demand exceeded supply in a large part of Texas in 1978 and 1980, resulting in the loss of trees, shrubs and turfgrass. Landscape losses such as these could be avoided with increased irrigation efficiency and utilization of landscape plants with lower consumptive water use. Cotter and Croft (4) have estimated

that homeowners apply up to 50% more water than is needed to maintain landscapes. This suggests a potential for significant water savings in urban landscapes if exact water requirements of landscape plants were known and communicated to homeowners. Landscaping with native plants offers possibilities for energy conservation through reduced requirements for water, fertilizer and pesticides because many adapted plants can be grown with low care and maintenance (3). The Texas Agricultural Experiment Station at Dallas[1/] has released four native plants to nurserymen for propagation and subsequent use in landscapes. Tipton and McWilliams (22) have indicated that another native plant (cresotebush) meets the requirements for inclusion in landscapes.

Although the amount of research regarding evapotranspiration (ET) by landscape plants is limited, studies by Tovey et al. (23) indicated ET values for bermudagrass ranging from 0.33 to 0.58 cm/day during the summer months in Nevada. In their study, two irrigations/week were required for turfgrass grown on sandy soil but only one irrigation per week was required for turfgrass grown on loam soil. Similar ET values were found in California (14). Kneebone and Pepper (13) found that the mean annual water use by St. Augustinegrass was 58% class A pan evaporation under Arizona conditions. In Colorado, water use by turf was influenced by mowing height, nitrogen,

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shade, species and soil properties (5). ET values are not available for such native grasses as buffalo grown under landscape conditions. A small amount of research regarding water use by landscape shrubs has been conducted and has been limited to non-native plants. Weatherspoon and Harrell (25) showed that several types of drip irrigation systems substantially reduced the amount of water applied compared to conventional sprinkler systems in irrigation of container grown non-native landscape plants. Water use determinations were not included in their studies. Miller et al. (15) developed an economic model that indicated least production cost for water for Ligustrum japonicum was obtained with 19.3 liters of water spread over a six-month production period. This resulted in water use amounting to 276 ml water/gram of dry plant material produced under Florida conditions. Several landscape plants have been grouped according to approximate water requirements (9) and this offers some insight as to consumptive use but quantification during the growing season would provide basis for further water savings.

Although ET values have not been obtained for native landscape plants, several methods have been used and much has been written concerning determination of ET for other crops. The ET values found for various field crops are not applicable to landscape plants but the techniques of estimation of water use by other plants can be modified for ET measurements of urban plants. Lysimeters appear to be the most desirable method of ET estimation providing they are properly constructed (10, 19, 20, 24). Lysimeters used for water use studies have ranged from elaborate weighing types (11, 18) to garbage cans (6)

and barrels (21) placed in the soil. Water use has also been successfully estimated by changes in soil-water content (7, 8, 12, 16, 17). Numerous methods are available for calculating ET. Some of the methods have been reviewed and discussed by Robins (19) and Tanner (20), however, the methods are usually compared to lysimeter or water balance data to check their accuracy.

Selection of a method of estimating water use by plants is governed by, (1) facilities available, (2) accuracy required, (3) type of crop, and (4) type of measurements to be made. In the studies with urban landscape plants it appears that data collected from weighing lysimeters with suction control and supplemented with water balance data obtained by drainage collection and soil moisture measurements is a feasible approach to water use determinations.

Objectives

1. To determine consumptive water use by a commercial cultivar and a native turfgrass grown under field conditions.
2. To determine consumptive water use by urban and native landscape plants under field conditions.
3. To determine water requirements of container grown urban and native landscape plants.

MATERIALS AND METHODS

Lysimeter installation

Lysimeters were installed by placing undisturbed soil cores into 0.6m dia X 0.9 m length metal cylinders constructed from 14 gauge steel. The cylinders were specially constructed straight sided 55 gal drums with rolled rims but without ends.

The cylinders were placed in a metal frame that furnished support and a cutting edge. To push the soil core into the cylinders, the cylinders were placed in the desired location then a heavy metal plate placed on top of the cylinder. Pressure was applied to push the cylinder into the soil by placing a back-hoe bucket on top of the metal plate and application of as much downward pressure as possible with the back-hoe. This pushed the cylinder into the soil to a depth of about 6 cm. The back-hoe was then used to dig a trench as close as possible on all sides of the cylinder. Shovels were then used to shave the soil down to slightly larger than the cylinder (Fig. 1). Downward pressure was again applied with the back-hoe. This resulted in soil being shaved off by the cutting edge as the cylinder moved downward. This procedure was repeated until the desired depth was reached (the cylinder moved about 10-20 cm each time). This procedure is essentially the same as that described by Brown et al (2) for large lysimeters. A 1.9 cm thick plywood circle was placed on top of soil core and held in place by 1.9 cm dia metal rods through holes drilled in the sides of the cylinder near the top. After reaching the desired depth, the cylinder and core was lifted with the back-hoe bucket by a

Fig. 1. Soil was shaved away from the cutting edge and frame in preparation for pushing the lysimeter into the soil to obtain an undisturbed soil core.

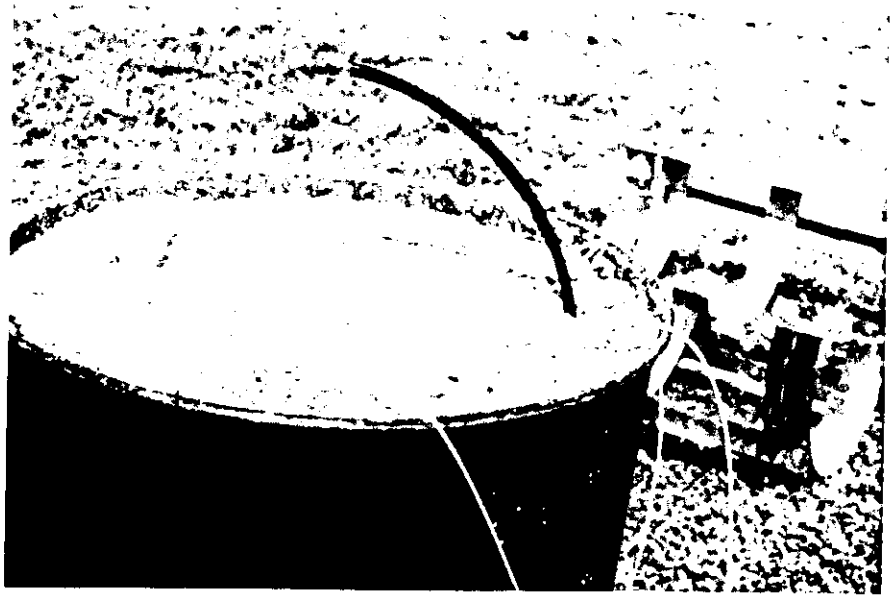

Fig. 2. Placement of the porous ceramic suction cups and tubing in the bottom of lysimeters.

chain attached to the metal frame. The cylinder and core were placed upside down and the frame and cutting tip removed. Enough soil was removed to allow a bottom to be placed on the cylinder. Before installing the bottom, three porous ceramic cups, to which nylon tubing had been attached (Fig. 2), was buried just below the soil surface and the nylon tubing passed through a common 1.27 cm dia hole from bottom to top of the soil core. The hole was drilled through the core with an auger then lined with polyvinyl tubing. After placement of the cups, silicone rubber cement was applied to the cylinder lip and a rubber gasket installed. Another layer of rubber cement was applied to the other side of the gasket before placing on the metal bottom and sealing it with a barrel clamp. The cores were then turned right side up and the plywood tops removed. Three equally spaced lifting ears were bolted to the top of each lysimeter. The ears were made from 0.635 cm thickness steel plate and were about 10 cm square with rounded corners and a 2 cm hole drilled for placement of lifting hooks.

Galvanized metal tanks (12 gauge) were buried in line on 3 m centers so that 5 cm of the upper rim was above soil level. The tanks were 4 cm larger in diameter than the cylinders holding the soil cores. The cylinders were placed inside the tanks (Fig. 3) and the area between the lysimeters and liner covered with removable sheet metal.

A tower for use in lifting the lysimeters was constructed from 0.5 cm thick steel I beam (10 x 15 cm). The tower was 2.75 m wide and 2.8 m high and the base was on 4 casters (Fig. 4). The tower supported an electric hoist, electronic crane scale (Measurement

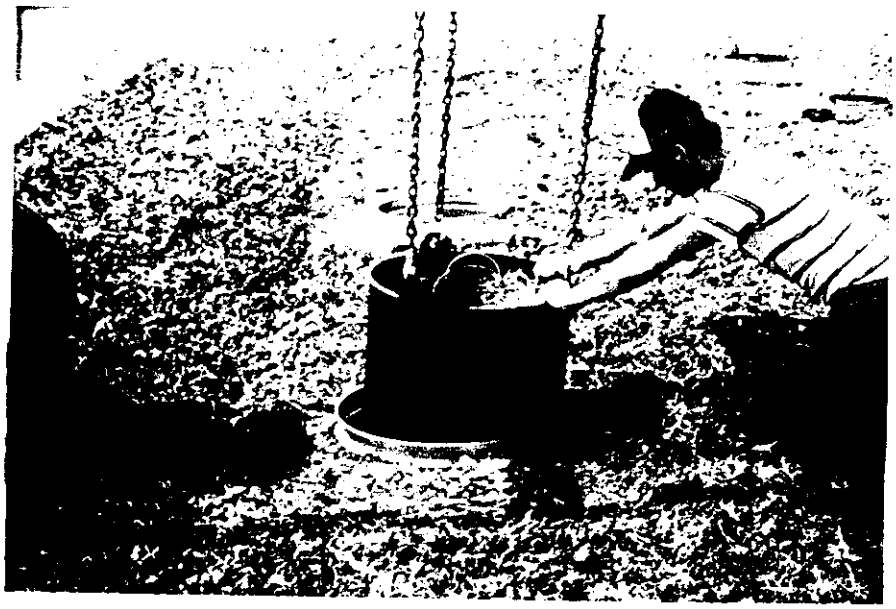

Fig. 3. Placing a lysimeter inside the metal liner.

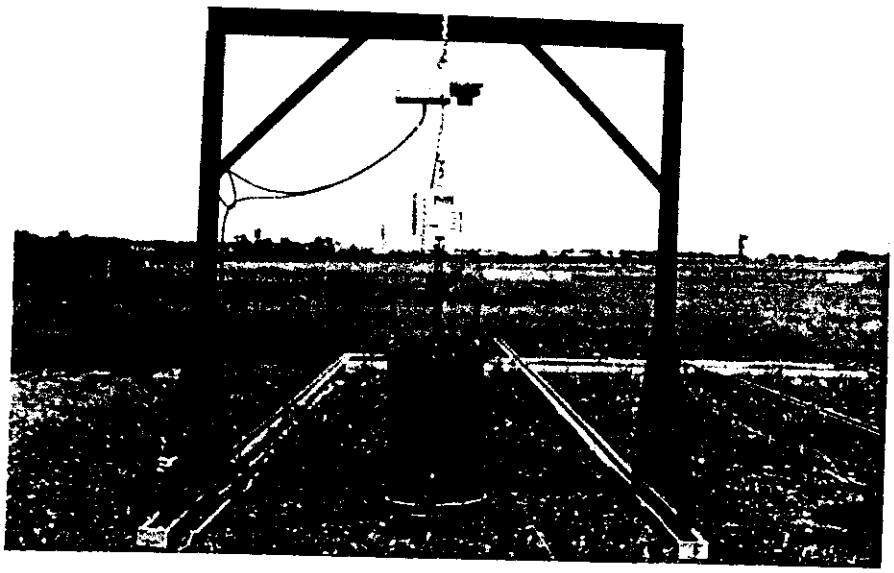

Fig. 4. Tower, weighing and lifting mechanism, and tracks used in weighing the lysimeters.

Systems International, Model 4260, Seattle, Wash.) and a chain attachment to hook onto the lysimeters for lifting and weighing. Wooden tracks were constructed on 3 m centers between the lysimeters to allow movement of the tower for lifting and weighing the lysimeters. The tracks were constructed from treated pine (2 X 6 bottom chanels and 2 X 4 sides). The tracks were connected at one end to allow lateral movement of the tower (Fig. 4). Two people were required to move the tower between lysimeters. Rooted cuttings of boxwood (Buxus microphylla var japonica), cenizo (Leucophyllum frutescens) and Texas barberry (Berberis swaseyi) were planted in 4 each of the lysimeters and St. Augustinegrass (Stenataphrum secundatum) and buffalograss (Buchloe dactyloides) was planted in 4 each of the lysimeters. The area surrounding each lysimeter was planted on 1 m centers with the same shrub that the lysimeter contained. A border area 3 rows (1 m/row) wide was planted to cenizo around the entire shrub area. A trickle irrigation system was installed for the shrubs outside the lysimeters but shrubs and grass inside the lysimeter were irrigated with measured amounts of water by hand. The area around the lysimeters containing grasses was planted in buffalograss. Turfgrasses were fertilized with 100 kgN/ha in June 1982 and May 1983. Shrubs were not fertilized.

A neutron probe access tube and tensiometers were placed in each lysimeter and two tensiometers were placed at 76 cm depth between the lysimeters in the shrub and grass area to obtain an estimate of soil moisture conditions outside lysimeters.

The tubes from the porous ceramic cups in each lysimeter were connected to a manifold and the manifold for each lysimeter connected to individual 18 liter containers by 0.31 cm dia nylon tubing. Suction was applied as required by a vacuum pump regulated by a vacuum switch. The collection bottles and vacuum system were housed in a building 35 m from the lysimeter site.

Irrigation Treatments and Data Collection

Evaporation (class A pan) and rainfall data were obtained from a weather station 200 m from the experimental site.

Water levels were imposed on each grass and shrub species in 1982 by 1) irrigating to field capacity when tensiometers at 30 cm depth read 0.30 bar and 2) when tensiometers at 76 cm depth read 0.40 bar. Each irrigation level was replicated two times for each species. Treatments in 1983 consisted of irrigation when tensiometers placed at 76 cm depth read 1) 0.25 and 2) 0.75 bar. However, malfunction of tensiometers resulted in three dry treatments (0.4 bar at 76 cm) on St. Augustinegrass in 1982 and one wet treatment (0.30 bar at 30 cm depth). Similar tensiometer malfunction in 1983 resulted in three dry buffalograss and one wet buffalograss teatment during May-July 1983.

Lysimeters were weighed and leachate collected at approximately weekly intervals from September 10, 1981 until December 4, 1981 and from June 4, 1982 until December 21, 1982. Daily weighing and leachate collections were made from August 10 to August 20, 1982. Monthly weighings were made in January, February and March 1983 then weekly weighings were made until July 15, 1983. Periodic soil moisture measurements were made by neutron probe during 1982.

Approximate dry matter of shrubs was determined on August 27, 1982 by cutting plants outside the lysimeters (of the same plant type) that were the same size as those in the lysimeters and obtaining their dry weights.

Container Grown Plants

Several native shrubs were screened for water use efficiency during 1981 and 1982. These studies were conducted by placing rooted cuttings or seedlings of the plants to be studied in 15 cm dia plastic pots (standard 1 gal pots) filled with 1/3 perlite and 2/3 Austin silty clay soil or 1:1 peat:perlite media. A 4 cm layer of perlite was placed on the surface of each pot to retard evaporation. Water use was determined by keeping account of irrigation volume and drainage volume for each pot. In some instances water use at various irrigation levels was determined. The water levels were regulated by tensiometer readings and/or weighing the pots. All treatments were replicated 4 or more times.

Transpiration Measurements

Limited measurements were made of transpiration rate by landscape plants under field conditions. These measurements were made with a LI 1600 steady state porometer.

Freeze Damage

Lysimeter installation was initiated in February 1981 and completed in July 1981. Shrubs and grass were planted in the lysimeters in July 1981. Limited water use data were obtained in the fall of 1981. The St. Augustinegrass was killed by severe cold during the winter of 1981 and was replanted in the spring of 1982.

Buffalograss was killed in the spring of 1982 by spraying with glyphosate then replanted so that St. Augustine and buffalograss would be started at the same time. Two cenizo in lysimeters were also killed by cold weather and replanted in the spring of 1982. Excessive rains in the spring and early summer of 1982 resulted in the first water use determinations being made on June 4. The remainder of 1982 was dry and ideal for these type water use studies.

RESULTS AND DISCUSSION

Water Use by Turfgrass

Evaporation data from a class A pan for the study period during 1981, 1982, and 1983 are given in Appendix Tables 1, 2, and 3. The data were used in calculation of relationships between pan evaporation and water use by turfgrass and shrubs.

Water level treatments were not applied during 1981 because plants were newly established and root systems were not well developed. Water use determinations were made, however. Water use by St. Augustinegrass during September 10 to December 4, 1981 ranged from 0.42 cm/day during the week ending September 17 to 0.12 cm/day during the week ending December 4 (Table 1). Water use by buffalograss during the same periods was 0.49 and 0.08 cm/day (Table 2).

The relationship between pan evaporation and water use by St. Augustinegrass for the period 9/10 - 12/4 could be described by the linear regression equations $\hat{y} = 0.46X+0.04$ where X = pan evaporation (cm) and $\hat{y}$ = water use (cm). The equation for buffalograss for the same period was $\hat{y} = 0.63X+0.06$. The r values obtained were 0.79 and 0.81 for St. Augustinegrass and buffalograss, respectively. A t test between water use by buffalograss and St. Augustinegrass indicated no difference in water use by the two grasses from Sept. 10 to Dec. 4, 1981.

St. Augustinegrass used slightly more water than buffalograss during 1982 ($t = 2.26$, 27 d.f.). The average difference was 0.03 cm/day. Total water use for the period 6/4/82 to 12/21/82 was 97.6 cm for St. Augustinegrass and 86.4 cm for buffalograss (Tables 3-6).

Table 1. Consumptive water use by newly established St. Augustinegrass from September to December 1981 at Dallas, TX.

Date	cm/Day				
	Lys 13	Lys 16	Lys 17	Lys 20	Avg
09/10	0.38	0.34	0.38	0.39	0.37
09/17	0.40	0.41	0.45	0.41	0.42
09/24	0.40	0.29	0.33	0.40	0.36
10/01	0.47	0.32	0.30	0.46	0.39
10/21	0.26	0.22	0.24	0.30	0.26
10/29	0.23	0.19	0.20	0.42	0.26
11/06	0.11	0.24	0.13	0.24	0.18
11/12	0.17	0.18	0.16	0.15	0.16
11/20	0.16	0.18	0.16	0.16	0.16
11/28	0.14	0.14	0.16	0.13	0.14
12/04	0.14	0.10	0.13	0.09	0.12

Table 2. Consumptive water use by newly established buffalograss from September to December 1981 at Dallas, TX.

Date	cm/Day				
	Lys 14	Lys 15	Lys 18	Lys 19	Avg
09/10	0.42	0.37	0.34	0.39	0.38
09/17	0.47	0.42	0.59	0.48	0.49
09/24	0.44	0.41	0.38	0.39	0.40
10/01	0.37	0.45	0.40	0.40	0.40
10/21	0.16	0.21	0.28	0.23	0.22
10/29	0.16	0.18	0.15	0.13	0.16
11/06	0.03	0.13	0.21	0.08	0.11
11/12	0.13	0.11	0.17	0.14	0.14
11/20	0.14	0.12	0.10	0.12	0.12
11/28	0.10	0.09	0.09	0.11	0.10
12/04	0.06	0.09	0.06	0.09	0.08

Table 3. Consumptive water use by buffalograss irrigated when soil moisture tension was 0.30 bar at 30 cm depth (1982).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 18	Lys 19	Avg	Lys 18	Lys 19	Avg	Lys 18	Lys 19	Avg
06/04	0.25	0.16	0.20	7.75	4.96	6.36	7.75	4.96	6.36
06/11	0.75	0.77	0.76	5.25	5.39	5.32	13.00	10.35	11.68
06/24	1.03	0.97	1.00	13.39	12.61	13.00	26.39	22.96	24.68
07/09	0.56	0.54	0.55	8.40	8.10	8.25	34.79	31.06	32.93
07/14	0.65	0.57	0.61	3.25	2.85	3.05	38.04	33.91	35.98
07/19	0.62	0.55	0.58	3.10	2.75	2.92	41.14	36.66	38.90
07/21	0.30	0.30	0.30	0.60	0.60	0.60	41.74	37.26	39.50
07/28	0.58	0.46	0.52	4.06	3.22	3.64	45.80	40.48	43.14
08/04	0.47	0.44	0.45	3.29	3.08	3.18	49.09	43.56	46.33
08/09	0.50	0.41	0.45	2.50	2.05	2.27	51.59	45.61	48.60
08/12	0.29	0.38	0.33	0.87	0.87	0.87	52.46	46.75	49.61
08/19	0.59	0.57	0.58	4.13	3.99	4.06	56.59	50.74	53.67
08/27	0.57	0.52	0.54	4.56	4.16	4.36	61.15	54.90	58.03
09/03	0.48	0.40	0.44	3.36	2.80	3.08	64.51	57.70	61.11
09/10	0.40	0.39	0.39	2.80	2.73	2.76	67.31	60.43	63.87
09/17	0.41	0.37	0.39	2.87	2.59	2.73	70.18	63.02	66.60
09/24	0.30	0.30	0.30	2.10	2.10	2.10	72.28.	65.12	68.70
10/01	0.23	0.21	0.22	1.61	1.47	1.54	73.89	66.59	70.24
10/13	0.32	0.26	0.29	3.84	3.12	3.48	77.73	69.71	73.72
10/15	0.21	0.20	0.20	0.42	0.40	0.41	78.15	70.11	74.13
11/01	0.19	0.37	0.28	3.23	6.29	4.76	81.38	76.40	78.89
11/09	0.56	0.58	0.57	4.48	4.64	4.56	85.86	81.04	83.45
11/16	0.14	0.16	0.15	0.98	1.12	1.05	86.84	82.16	84.50
11/22	0.04	0.06	0.05	0.24	0.36	0.30	87.08	82.52	84.80
11/29	0.24	0.19	0.21	1.68	1.33	1.50	88.76	83.85	86.31
12/06	0.22	0.26	0.24	1.54	1.82	1.68	90.30	85.67	87.99
12/15	0.27	0.11	0.19	2.43	0.99	1.71	92.73	86.66	89.70
12/21	0.08	0.03	0.05	0.48	0.18	0.33	93.21	86.84	90.03

Table 4. Consumptive water use by buffalograss irrigated when soil moisture tension was 0.40 bar at 76 cm depth (1982).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 14	Lys 19	Avg	Lys 14	Lys 19	Avg	Lys 14	Lys 19	Avg
06/04	0.03	0.08	0.05	0.93	2.48	1.71	0.93	2.48	1.71
06/11	0.77	0.69	0.73	5.39	4.83	5.11	6.32	7.31	6.82
06/24	1.03	0.98	1.00	13.39	12.74	13.06	19.71	20.05	19.88
07/09	0.58	0.43	0.50	8.70	6.45	7.58	28.41	26.50	27.46
07/14	0.67	0.53	0.60	3.35	2.65	3.00	31.76	29.15	30.46
07/19	0.64	0.50	0.57	3.20	2.50	2.85	34.96	31.65	33.31
07/21	0.35	0.30	0.32	0.70	0.60	0.65	35.66	32.25	33.96
07/28	0.57	0.52	0.54	3.99	3.64	3.81	39.65	35.89	37.77
08/04	0.44	0.39	0.41	3.08	2.73	2.90	42.73	38.62	40.68
08/09	0.50	0.45	0.47	2.50	2.25	2.37	45.23	40.87	43.05
08/12	0.30	0.34	0.32	0.90	1.02	0.96	46.13	41.89	44.01
08/19	0.59	0.49	0.54	4.13	3.43	3.78	50.26	45.32	47.79
08/27	0.51	0.54	0.52	4.08	4.32	4.20	54.34	49.64	51.99
09/03	0.44	0.46	0.45	3.08	3.22	3.15	57.42	52.86	55.14
09/10	0.41	0.38	0.39	2.87	2.66	2.76	60.29	55.52	57.91
09/17	0.36	0.25	0.30	2.52	1.75	2.13	62.81	57.27	60.04
09/24	0.32	0.37	0.34	2.24	2.59	2.41	65.05	59.86	62.46
10/01	0.24	0.28	0.26	1.68	1.96	1.82	66.73	61.82	64.28
10/13	0.32	0.27	0.29	3.84	3.24	3.54	70.57	65.06	67.82
10/15	0.13	0.12	0.12	0.26	0.24	0.25	70.83	65.30	68.07
11/01	0.26	0.17	0.21	4.42	2.89	3.65	75.25	68.19	71.72
11/09	0.35	0.40	0.37	2.80	3.20	3.00	78.05	71.39	74.72
11/16	0.22	0.19	0.20	1.54	1.33	1.43	79.59	72.72	76.16
11/22	0.06	0.04	0.05	0.36	0.24	0.30	79.95	72.96	76.46
11/29	0.30	0.21	0.25	2.10	1.47	1.78	82.05	74.43	78.24
12/06	0.23	0.25	0.24	1.61	1.75	1.68	83.66	76.18	79.92
12/15	0.27	0.12	0.19	2.43	1.08	1.75	86.09	77.26	81.68
12/21	0.09	0.26	0.17	0.54	1.56	1.05	86.63	78.82	82.73

Table 5. Consumptive water use by St. Augustinegrass irrigated when soil moisture tension was 0.30 bar at 30 cm depth (1982).

Date	cm Water Use/Day Lys 20	cm Water Use/Period Lys 20	Cumulative Use (cm) Lys 20
06/04	0.36	11.16	11.16
06/11	0.79	5.53	16.69
06/24	1.02	13.26	29.95
07/09	0.47	7.05	37.00
07/14	0.64	3.20	40.20
07/19	0.56	2.80	43.00
07/21	0.41	0.82	43.82
07/28	0.52	3.64	47.46
08/04	0.45	3.15	50.61
08/09	0.49	2.45	53.06
08/12	0.29	0.87	53.93
08/19	0.58	4.06	57.99
08/27	0.57	4.56	62.55
09/03	0.54	3.78	66.33
09/10	0.34	2.38	68.71
09/17	0.44	3.08	71.79
09/24	0.34	2.38	74.17
10/01	0.30	2.10	76.27
10/13	0.31	3.72	79.99
10/15	0.19	0.38	80.37
11/01	0.21	3.57	83.94
11/09	0.46	3.68	87.62
11/16	0.20	1.40	89.02
11/22	0.01	0.06	89.08
11/29	0.26	1.82	90.90
12/06	0.28	1.96	92.86
12/15	0.25	2.25	95.11
12/21	0.17	1.02	96.13

Table 6. Consumptive water use by St. Augustinegrass irrigated when soil moisture tension was 0.4 bar at 76 cm depth (1982).

Date	cm Water Use/Day				cm Water Use/Period				Cumulative Use (cm)			
	Lys 13	Lys 16	Lys 17	Avg	Lys 13	Lys 16	Lys 17	Avg	Lys 13	Lys 16	Lys 17	Avg
06/04	0.31	0.37	0.47	0.38	11.47	14.57	11.78	12.61	11.47	14.57	11.78	12.61
06/11	0.78	0.82	0.89	0.83	5.46	5.74	6.23	5.81	16.93	20.31	18.01	18.42
06/24	1.06	1.05	1.07	1.06	13.78	13.65	13.91	13.78	30.71	33.96	31.92	32.20
07/09	0.59	0.59	0.65	0.61	8.85	8.85	9.75	9.15	39.56	42.81	41.67	41.35
07/14	0.60	0.62	0.65	0.62	3.00	3.10	3.25	3.12	42.56	45.91	44.92	44.47
07/19	0.22	0.55	0.66	0.48	1.10	2.75	3.30	2.38	43.66	48.66	48.22	46.85
07/21	0.40	0.48	0.32	0.40	0.80	0.96	1.92	1.23	44.46	49.62	50.14	48.08
07/28	0.45	0.55	0.67	0.56	3.15	3.85	4.69	3.90	47.61	53.47	54.83	51.98
08/04	0.46	0.45	0.47	0.46	3.22	3.15	3.29	3.22	50.83	56.62	58.12	55.20
08/09	0.53	0.55	0.52	0.53	2.65	2.75	2.60	2.67	53.48	59.37	60.72	57.87
08/12	0.30	0.34	0.26	0.30	0.90	1.0	0.78	0.90	54.38	60.37	61.50	58.77
08/19	0.56	0.57	0.58	0.57	3.92	3.99	4.06	3.99	58.30	64.36	65.56	62.76
08/27	0.51	0.58	0.59	0.56	4.08	4.64	4.72	4.48	62.38	69.00	70.28	67.24
09/03	0.55	0.45	0.57	0.52	3.85	3.15	3.99	3.66	66.23	72.15	74.27	70.90
09/10	0.40	0.41	0.38	0.40	2.80	2.87	2.66	2.78	69.03	75.02	76.93	73.68
09/17	0.35	0.39	0.44	0.39	2.45	2.73	3.08	2.75	71.48	77.75	80.01	76.43
09/24	0.33	0.29	0.33	0.32	2.31	2.03	2.31	2.22	73.79	79.78	82.32	78.65
10/01	0.33	0.28	0.31	0.31	2.31	1.96	2.17	2.15	76.10	81.74	84.49	80.80
10/13	0.26	0.16	0.26	0.23	3.12	1.92	3.12	2.72	79.22	83.66	87.61	83.52
10/15	0.21	0.19	0.20	0.20	0.42	0.38	0.40	0.40	79.64	84.04	88.01	83.92
11/01	0.21	0.18	0.20	0.20	3.57	3.06	3.40	3.34	83.21	87.10	91.41	87.26
11/09	0.33	0.31	0.29	0.31	2.64	2.48	2.32	2.48	85.85	89.58	93.73	89.74
11/16	0.23	0.19	0.27	0.23	1.61	1.33	1.89	1.61	87.46	90.91	95.62	91.35
11/22	0.07	0.06	0.06	0.06	0.42	0.36	0.36	0.38	87.88	91.27	95.98	91.73
11/29	0.24	0.28	0.21	0.24	1.68	1.96	1.47	1.70	89.56	93.23	97.45	93.43
12/06	0.21	0.23	0.27	0.24	1.47	1.61	1.89	1.66	91.03	94.84	99.34	95.09
12/15	0.14	0.14	0.38	0.22	1.26	1.26	3.42	1.98	92.29	96.10	102.76	97.07
12/21	0.12	0.19	0.20	0.17	0.72	1.14	1.20	1.02	93.01	97.24	103.96	98.09

Paired t tests of water use by St. Augustinegrass irrigated at 0.4 bar at 76 cm depth vs. water use by St. Augustinegrass irrigated at 0.30 bar at 30 cm depth indicated no significant difference in water use between the two irrigation treatments in 1982. The same was true for buffalograss.

The relationship between water use (avg of 4 lysimeters/species) by St. Augustinegrass and buffalograss and evaporation from a class A pan from 9/10 to 12/4/81 and from 6/4 to 12/21/82 is shown in Fig. 5. These data indicate that consumptive water use by the two grass species was about 0.5 pan evaporation during the measurement periods of 1981 and 1982.

These data suggest that the soil moisture regimes during the study were too wet to detect differences in consumptive water use due to soil moisture. The root system of either grass may not have been fully developed since the grasses were established initially in the fall of 1981 and again in the spring of 1982. The main difference in water requirements of these two grasses may be drought tolerance and not water use under unlimited moisture. Buffalograss irrigated when soil moisture was 0.40 bar at 76 cm maintained higher turf quality during 1982 (visual rating) than St. Augustinegrass with the same irrigation treatment. Buffalograss retained its dark green color and turgor throughout the summer whereas, St. Augustinegrass was pale and wilted under the dry treatment.

The limited amount of water use data obtained for turfgrasses from May to July 1983 (Tables 7-10) indicated significant but different relationships between pan evaporation and wet and dry

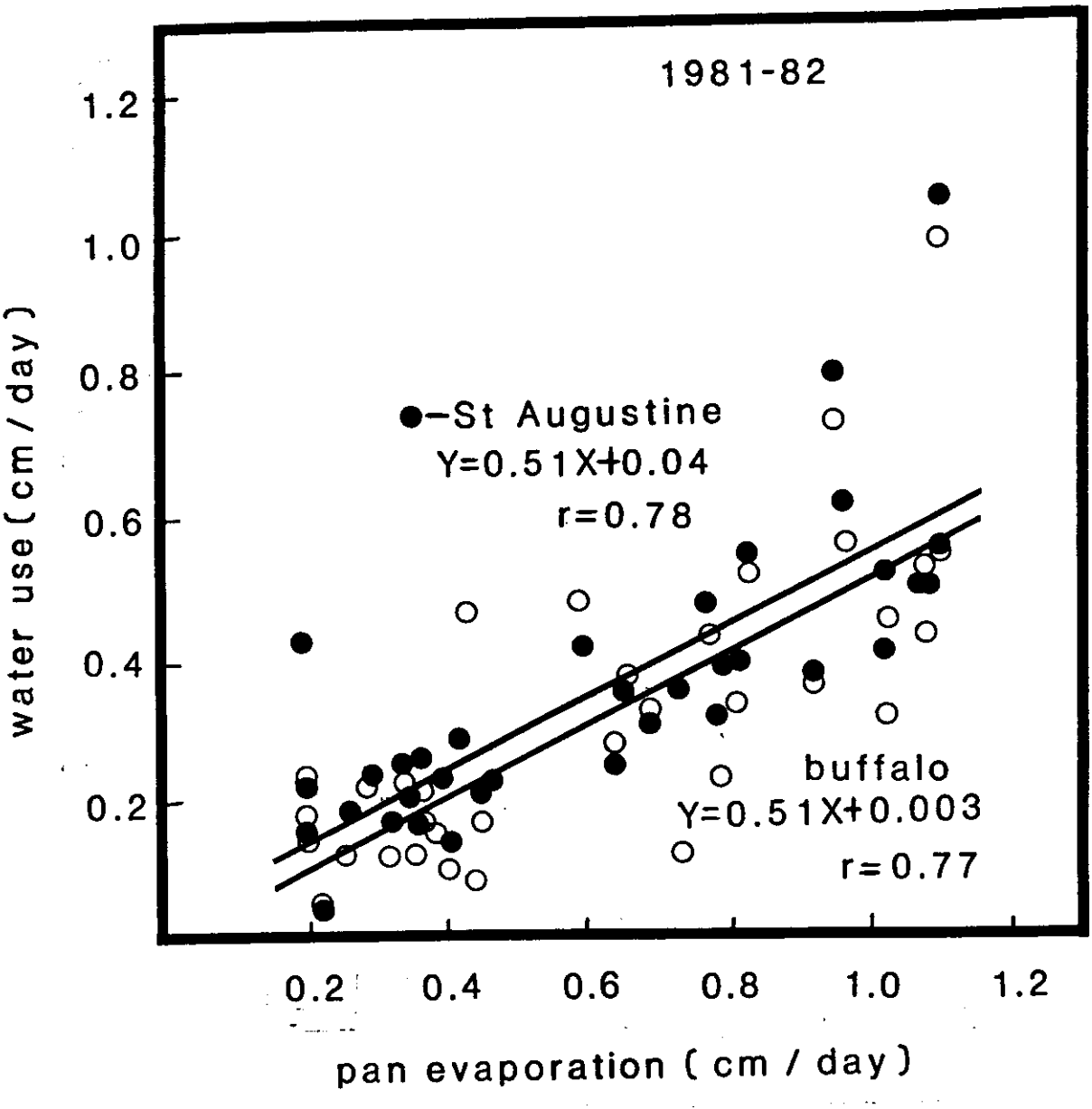

Fig. 5. Relationship between pan evaporation and water use by St. Augustinegrass and buffalograss.

Table 7. Consumptive water use by buffalograss irrigated when soil moisture tension was 0.25 bar at 76 cm depth (1983).

Date	cm Water Use/Day Lys 15	cm Water Use/Period Lys 15	Cumulative Use (cm) Lys 15
01/11	.07	1.47	1.47
02/03	.09	2.07	3.54
03/14	.09	3.51	7.05
03/29	.19	2.85	9.90
04/11	.20	2.60	12.50
04/18	.23	1.61	14.11
04/25	.14	.98	15.09
05/09	.35	4.90	19.99
05/16	.23	1.61	21.60
05/26	.56	5.60	27.20
06/03	.43	3.44	30.64
06/09	.48	2.88	33.52
06/16	.61	4.27	37.79
06/23	.57	3.99	41.78
06/30	.55	3.85	45.63
07/07	.65	4.55	50.18
07/15	.52	4.16	54.34

Table 8. Consumptive water use by buffalograss irrigated when soil moisture tension was 0.75 bar at 76 cm depth (1983).

Date	cm Water Use/Day Lysimeter # 14	18	19	Avg.	cm Water Use/Period Lysimeter # 14	18	19	Avg.	Cumulative Use (cm) Lysimeter # 14	18	19	Avg.
01/11	.07	.13	.11	.10	1.47	2.73	2.31	2.17	1.47	2.73	2.31	2.17
02/03	.07	.10	.07	.08	1.61	2.30	1.61	1.84	3.08	5.03	3.92	4.01
03/14	.08	.08	.07	.08	3.12	3.12	2.73	2.99	6.20	8.15	6.65	7.00
03/29	.15	.14	.12	.14	2.25	2.10	1.80	2.05	8.45	10.25	8.45	9.05
04/11	.14	.12	.11	.12	1.82	1.56	1.43	1.60	10.27	11.81	9.88	10.65
04/18	.26	.22	.25	.24	1.82	1.54	1.75	1.70	12.09	13.35	11.63	12.36
04/25	.14	.15	.11	.13	.98	1.05	.77	.93	13.07	14.40	12.40	13.29
05/09	.37	.32	.30	.33	5.18	4.48	4.20	4.62	18.25	18.88	16.60	17.91
05/16	.30	.22	.20	.24	2.10	1.54	1.40	1.68	20.35	20.42	18.00	19.59
05/26	.47	.44	.42	.44	4.70	4.40	4.20	4.43	25.05	24.82	22.20	24.02
06/03	.41	.40	.36	.39	3.28	3.20	2.88	3.12	28.33	28.02	25.08	27.14
06/09	.52	.48	.43	.48	3.12	2.88	2.58	2.86	31.45	30.90	27.66	30.00
06/16	.56	.55	.54	.55	3.92	3.85	3.78	3.85	35.37	34.75	31.44	33.85
06/23	.48	.48	.45	.47	3.36	3.36	3.15	3.29	38.73	38.11	34.59	37.14
06/30	.44	.45	.49	.46	3.08	3.15	3.43	3.22	41.81	41.26	38.02	40.36
07/07	.43	.53	.49	.48	3.01	3.71	3.43	3.38	44.82	44.97	41.45	43.75
07/15	.41	.40	.49	.43	3.28	3.20	3.92	3.47	48.10	48.17	45.37	47.21

Table 9. Consumptive water use by St. Augustinegrass irrigated when moisture tension was 0.25 bar at 76 cm depth (1983).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 13	Lys 20	Avg	Lys 13	Lys 20	Avg	Lys 13	Lys 20	Avg
01/11	.11	.15	.13	2.31	3.15	2.73	2.31	3.15	2.73
02/03	.09	.15	.12	2.07	3.45	2.76	4.38	6.60	5.49
03/14	.10	.13	.12	3.90	5.07	4.49	8.28	11.67	9.98
03/29	.15	.16	.16	2.25	2.40	2.33	10.53	14.07	12.30
04/11	.18	.17	.18	2.34	2.21	2.28	12.87	16.28	14.58
04/18	.20	.22	.21	1.40	1.54	1.47	14.27	17.82	16.05
04/25	.11	.11	.11	.77	.77	.77	15.04	18.59	16.82
05/09	.30	.28	.29	4.20	3.92	4.06	19.24	22.51	20.88
05/16	.22	.22	.22	1.54	1.54	1.54	20.78	24.05	22.42
05/26	.47	.59	.53	4.70	5.90	5.30	25.48	29.95	27.72
06/03	.40	.40	.40	3.20	3.20	3.20	28.68	33.15	30.92
06/09	.49	.50	.50	2.94	3.00	2.97	31.62	36.15	33.89
06/16	.57	.61	.59	3.99	4.27	4.13	35.61	40.42	38.02
06/23	.57	.55	.56	3.99	3.85	3.92	39.60	44.27	41.94
06/30	.55	.59	.57	3.85	4.13	3.99	43.45	48.40	45.93
07/07	.61	.76	.69	4.27	5.32	4.80	47.72	53.72	50.72
07/15	.54	.59	.57	4.32	4.72	4.52	52.04	58.44	55.24

Table 10. Consumptive water use by St. Augustinegrass irrigated when soil moisture tension was 0.75 bar at 76 cm depth (1983).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 16	Lys 17	Avg	Lys 16	Lys 17	Avg	Lys 16	Lys 17	Avg
01/11	.12	.08	.10	2.52	1.68	2.10	2.52	1.68	2.10
02/03	.10	.13	.12	2.30	2.99	2.65	4.82	4.67	4.75
03/14	.11	.12	.12	4.29	4.68	4.49	9.11	9.35	9.23
03/29	.16	.14	.15	2.40	2.10	2.25	11.51	11.45	11.48
04/11	.19	.20	.20	2.47	2.60	2.54	13.98	14.05	14.02
04/18	.18	.22	.20	1.26	1.54	1.40	15.24	15.59	15.42
04/25	.10	.13	.12	.70	.91	.81	15.94	16.50	16.22
05/09	.25	.30	.28	3.50	4.20	3.85	19.44	20.70	20.07
05/16	.24	.23	.24	1.68	1.61	1.65	21.12	22.31	21.72
05/26	.44	.46	.45	4.40	4.60	4.50	25.52	26.91	26.22
06/03	.39	.39	.39	3.12	3.12	3.12	28.64	30.03	29.34
06/09	.50	.49	.50	3.00	2.94	2.97	31.64	32.97	32.31
06/16	.57	.60	.59	3.99	4.20	4.10	35.63	37.17	36.40
06/23	.54	.53	.54	3.78	3.71	3.75	39.41	40.88	40.15
06/30	.51	.48	.50	3.57	3.36	3.47	42.98	44.24	43.61
07/07	.60	.48	.54	4.20	3.36	3.78	47.18	47.60	47.39
07/15	.47	.49	.48	3.76	3.92	3.84	50.94	51.52	51.23

treatments for St. Augustinegrass and buffalograss. The relationships for wet (irrigated at 0.25 bar tension at 76 cm depth) St. Augustine and buffalograss could be described by the regression equations $\hat{y}$ = 0.72X-0.094 (r=0.83) and $\hat{y}$ = 0.59X-0.02 (r=0.86) for St. Augustine and buffalograss, respectively. The relationships for the dry (irrigated at 0.75 bar tension at 76 cm depth) treatments were $\hat{y}$=0.58X-0.02 (r=0.84) and $\hat{y}$ = 0.42X-0.08 (r=0.84) for St. Augustine and buffalograss respectively. The differences that appeared between wet and dry treatments of both species in 1983 may have been due to establishment of a more extensive root system than in previous years and to irrigation treatments that resulted in greater soil moisture tension in 1983. Studies of this type should be conducted over a several year period to obtain water use values under various environmental and edaphic conditions.

Water Use By Shrubs

During the fall of 1981, water use by all shrubs was similar because they were small and relatively uniform in size (10-15 cm tall), (Tables 11-13). Water use by boxwood during the fall of 1981 ranged from 0.33 cm/day during the week ending October 21 to 0.06 cm/day during the week ending November 28 (Table 11). Water use by cenizo during the study period of 1981 was greatest (0.38 cm/day) during the week ending September 17 and least (0.10 cm/day) during the week ending November 28 (Table 12). Water use by Texas barberry ranged from 0.31 cm/day during week ending October 21 to 0.06 cm/day during the week ending November 28, 1981 (Table 13). In 1982 there was considerable growth differential particularly in cenizo. By

Table 11. Consumptive water use by newly established boxwood from September to December 1981 at Dallas, TX.

Date	cm/Day				
	Lys 2	Lys 6	Lys 7	Lys 11	Avg
09/10	0.32	0.29	0.29	0.38	0.32
09/17	0.32	0.29	0.29	0.31	0.30
09/24	0.13	0.12	0.12	0.15	0.13
10/01	0.15	0.40	0.40	0.16	0.28
10/21	0.24	0.41	0.41	0.26	0.33
10/29	0.20	0.23	0.23	0.26	0.23
11/06	0.31	0.28	0.28	0.36	0.31
11/12	0.16	0.15	0.15	0.22	0.17
11/20	0.12	0.11	0.11	0.15	0.12
11/28	0.08	0.06	0.06	0.06	0.06
12/04	0.16	0.15	0.15	0.15	0.15

Table 12. Consumptive water use by newly established cenizo from September to December 1981 at Dallas, TX.

Date	cm/Day				
	Lys 3	Lys 4	Lys 8	Lys 12	Avg
09/10	0.30	0.39	0.47	0.32	0.37
09/17	0.36	0.42	0.47	0.28	0.38
09/24	0.23	0.25	0.29	0.13	0.22
10/01	0.44	0.26	0.58	0.13	0.35
10/21	0.36	0.28	0.43	0.26	0.33
10/29	0.13	0.24	0.21	0.25	0.21
11/06	0.25	0.31	0.36	0.29	0.30
11/12	0.05	0.19	0.22	0.16	0.16
11/20	0.18	0.16	0.20	0.13	0.17
11/28	0.06	0.10	0.15	0.07	0.10
12/04	0.17	0.18	0.18	0.11	0.16

Table 13. Consumptive water use by newly established Texas barberry from September to December 1981 at Dallas, TX.

Date	cm/Day				
	Lys 1	Lys 5	Lys 9	Lys 10	Avg
09/10	0.29	0.26	0.29	0.33	0.29
09/17	0.26	0.28	0.33	0.29	0.29
09/24	0.12	0.11	0.11	0.12	0.12
10/01	0.33	0.10	0.11	0.44	0.24
10/21	0.31	0.27	0.24	0.41	0.31
10/29	0.14	0.19	0.20	0.15	0.17
11/06	0.12	0.32	0.34	0.26	0.26
11/12	0.15	0.13	0.20	0.18	0.16
11/20	0.11	0.09	0.12	0.13	0.11
11/28	0.08	0.05	0.06	0.04	0.06
12/04	0.13	0.16	0.11	0.18	0.14

August 27, height plus width of cenizo ranged from 66 to 127 cm. The size range of boxwood and Texas barberry at that time was 64 to 74 cm and 47 to 79 cm, respectively (Table 14). Consumptive water use by shrubs in 1982 was a function of size and growth rate (Fig. 6). The fast growing cenizo used from 160 to 360 l/plant from May 14 to November 1. There was a poor correlation between water use by shrubs and pan evaporation, however, as size of cenizo plants increased, the degree of correlation increased (Fig. 7). The r value for cenizo weighing 23 g in August was 0.37 but increased to 0.51 for plants weighing 172 g. The size range for boxwood and barberry was too narrow to develop such a relationship. Part of the variation in size of cenizo was a result of winter kill and replanting 2 of the cenizo plants. The two small plants were replanted in the spring of 1982 and were designated as the wet treatment because of difficulties in establishment of new plants under dry treatment conditions. The plants established in 1981 had a much faster growth rate which resulted in greater water use. Boxwood grown under the low moisture regime appeared wilted and had a less pleasing appearance than boxwood grown at higher water levels. Water use by dry boxwood was slightly less than the wet boxwood although growth rate was the same. Moisture levels maintained in these studies did not influence the visual rating of barberry or cenizo. Water use by the shrubs in 1982 is given in Tables 15-20.

During May to July 1983, water use by shrubs ranged from 20.0 cm for cenizo irrigated at 0.75 bar at 76 cm depth to 41.8 cm for cenizo irrigated at 0.75 bar at 76 cm depth. Water use from May to July 1983

Table 14. Size of shrubs in the lysimeters on various dates.

	Height plus width			
	g/plant 8/27/82	cm 8/27/82	cm 4/15/83	cm 7/15/83
Boxwood (wet)*				
Lysimeter 6	82	71	96	102
Lysimeter 7	47	64	89	91
Boxwood (dry)				
Lysimeter 2	82	74	76	84
Lysimeter 11	47	68	74	81
Texas barberry (wet)				
Lysimeter 1	18	79	96	124
Lysimeter 10	24	69	104	145
Texas barberry (dry)				
Lysimeter 5	31	58	63	107
Lysimeter 9	14	47	64	122
Cenizo (wet)				
Lysimeter 4	23	68	91	102
Lysimeter 12	44	66	99	107
Cenizo (wet)				
Lysimeter 3	133	96	119	99**
Lysimeter 8	172	127	142	142

*Wet = irrigated at 0.30 bar moisture tension at 30 cm depth.
Dry = irrigatd at 0.40 bar tension at 76 cm depth.
**Freeze Damage.

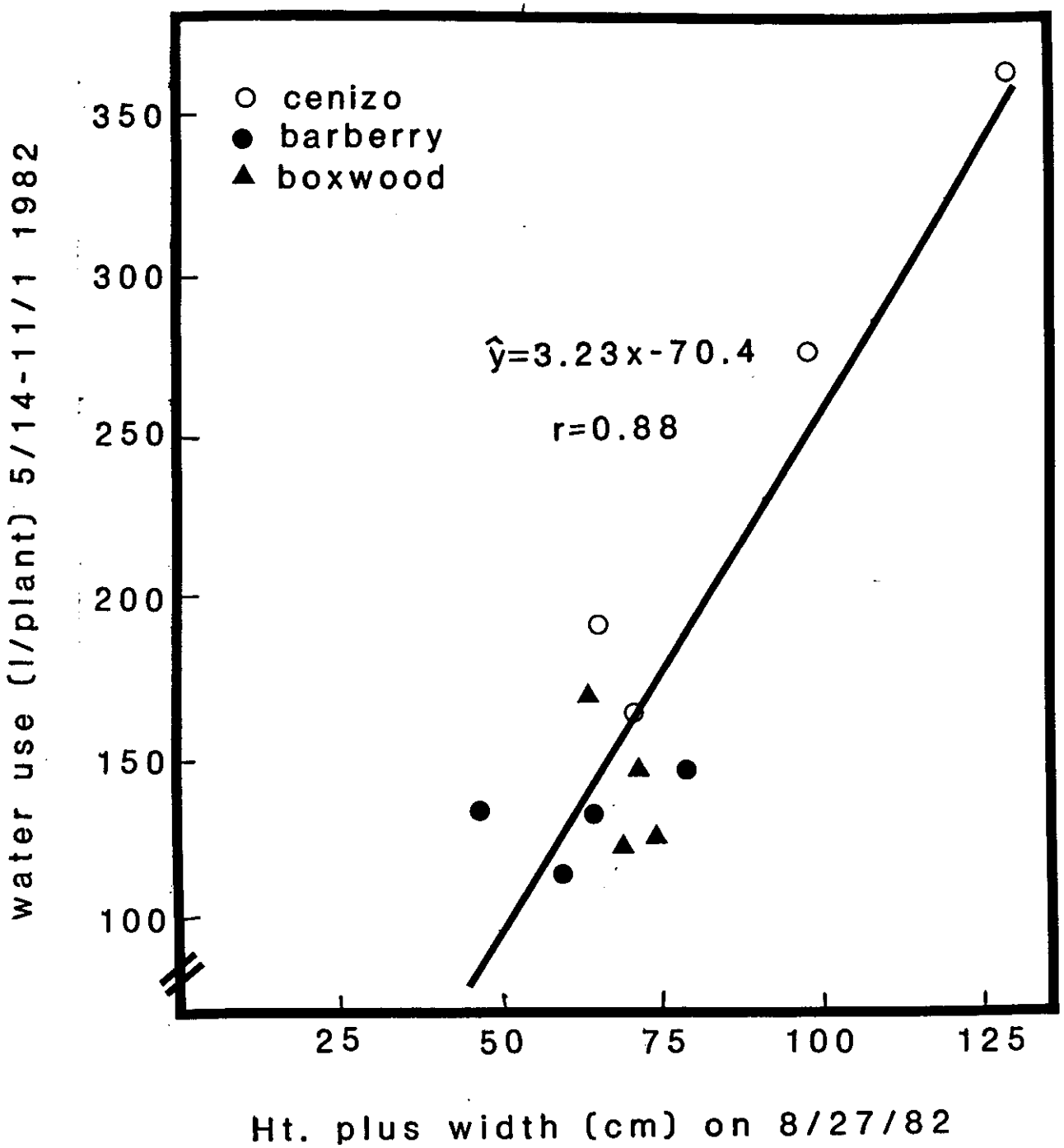

Fig. 6. Relationship between shrub size and water use by 3 landscape plants.

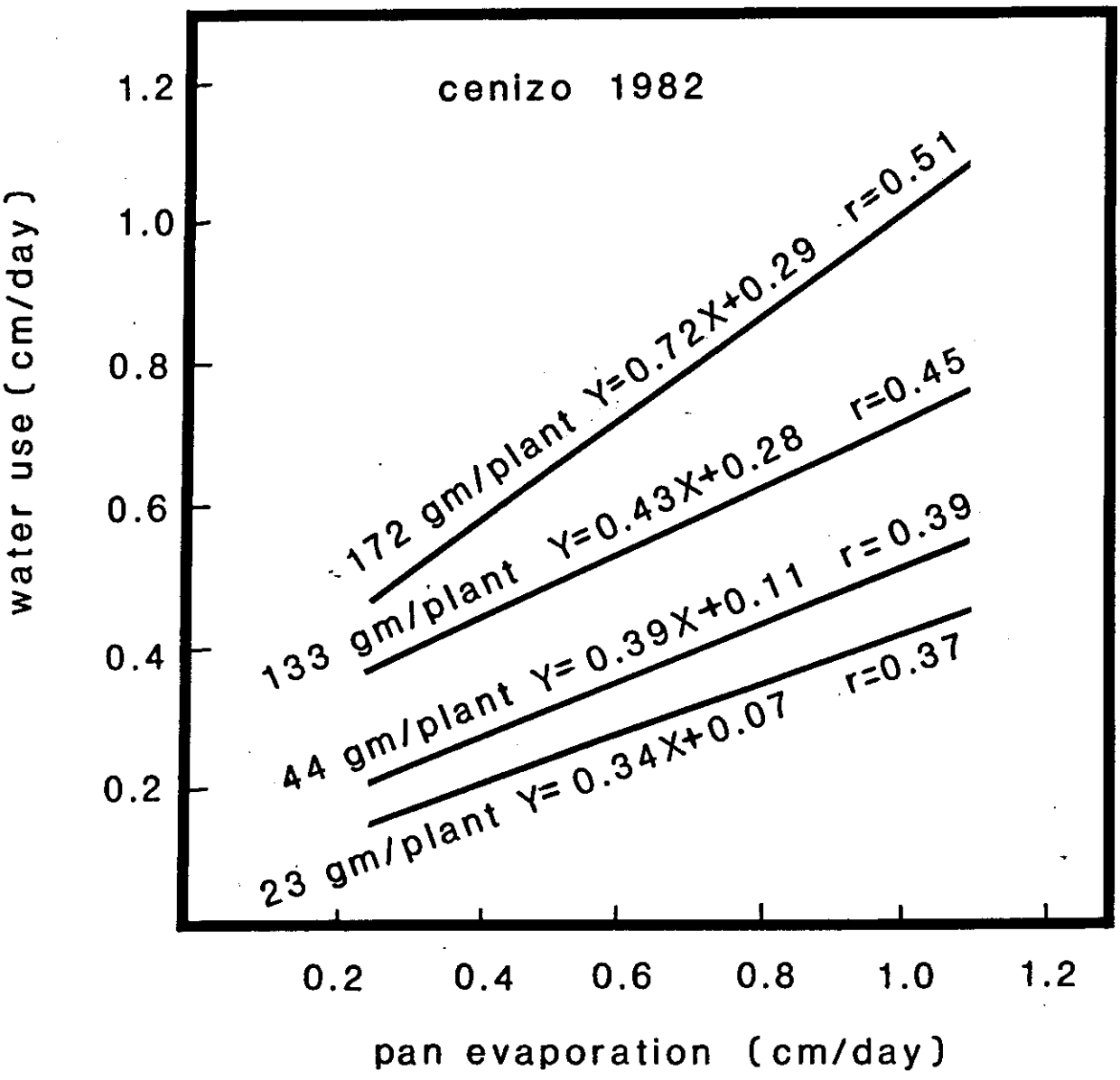

Fig. 7. Relationship between pan evaporation and water use by cenizo as influenced by plant size.

Table 15. Consumptive water use by Texas barberry irrigated when soil moisture tension was 0.30 bar at 30 cm depth (1982).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 1	Lys 10	Avg	Lys 1	Lys 10	Avg	Lys 1	Lys 10	Avg
06/04	0.20	0.40	0.30	6.20	12.40	9.30	6.20	12.40	9.30
06/11	0.61	0.65	0.63	4.27	4.55	4.41	10.47	16.95	13.71
06/24	0.92	0.90	0.91	11.96	11.70	11.83	22.43	28.65	25.54
07/09	0.35	0.29	0.32	5.25	4.35	4.80	27.68	33.00	30.34
07/14	0.27	0.28	0.28	1.35	1.40	1.37	29.03	34.40	31.72
07/19	0.22	0.17	0.20	1.10	0.85	0.98	30.13	35.25	32.69
07/21	0.42	0.35	0.37	0.84	0.70	0.77	30.97	35.95	33.46
07/28	0.23	0.19	0.21	1.61	1.33	1.47	32.58	37.28	34.93
08/04	0.25	0.12	0.18	1.75	0.84	1.30	34.33	38.12	36.23
08/09	0.23	0.13	0.18	1.15	0.65	0.90	35.48	38.77	37.13
08/12	0.21	0.14	0.17	0.63	0.42	0.52	36.11	39.19	37.65
08/19	0.37	0.27	0.32	2.59	1.89	2.24	38.70	41.08	39.89
08/17	0.37	0.15	0.26	2.96	1.20	2.08	41.66	42.28	41.97
09/03	0.37	0.16	0.27	2.59	1.12	1.86	44.25	43.40	43.83
09/10	0.25	0.08	0.17	1.75	0.56	1.16	46.00	43.96	44.98
09/17	0.29	0.29	0.29	2.03	2.03	2.03	48.03	45.99	47.01
09/24	0.25	0.23	0.24	1.75	1.61	1.68	49.78	47.60	48.69
10/01	0.18	0.09	0.14	1.26	0.63	0.94	51.04	48.23	49.64
10/13	0.36	0.19	0.27	4.32	2.28	3.30	55.36	50.51	52.94
10/15	0.32	0.29	0.30	0.64	0.58	0.61	56.00	51.09	53.55
11/01	0.14	0.19	0.17	2.38	3.23	2.80	58.38	54.32	56.35
11/09	0.32	0.31	0.31	2.56	2.48	2.52	60.94	56.80	58.87
11/16	0.25	0.26	0.25	1.75	1.82	1.78	62.69	58.62	60.66
11/22	0.08	0.08	0.08	0.48	0.48	0.48	63.17	59.10	61.14
11/29	0.25	0.19	0.22	1.75	1.33	1.54	64.92	60.43	62.68
12/06	0.20	0.16	0.18	1.40	1.12	1.26	66.32	61.55	63.94
12/15	0.13	0.13	0.13	1.17	1.17	1.17	67.49	62.72	65.11
12/21	0.14	0.12	0.13	0.84	0.72	0.78	68.33	63.44	65.89

Table 16. Consumptive water use by Texas barberry irrigated when soil moisture tension was 0.40 bar at 76 cm depth (1982).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative use (cm)		
	Lys 5	Lys 9	Avg	Lys 5	Lys 9	Avg	Lys 5	Lys 9	Avg
06/04	0.31	0.36	0.33	9.61	11.16	10.39	9.61	11.16	10.39
06/11	0.58	0.59	0.58	4.06	4.13	4.09	13.67	15.29	14.48
06/24	0.90	0.91	0.90	11.70	11.83	11.76	25.37	27.12	26.25
07/09	0.28	0.25	0.27	4.20	3.75	3.98	29.57	30.87	30.22
07/14	0.22	0.31	0.26	1.10	1.55	1.32	30.67	32.42	31.55
07/19	0.17	0.15	0.16	0.85	0.75	0.80	31.52	33.17	32.35
07/21	0.33	0.25	0.29	0.66	0.50	0.58	32.18	33.67	32.93
07/28	0.17	0.09	0.13	1.19	0.63	0.91	33.37	34.30	33.84
08/04	0.13	0.04	0.09	0.91	0.28	0.60	34.28	34.58	34.43
08/09	0.12	0.12	0.12	0.60	0.60	0.60	34.88	35.18	35.03
08/12	0.08	0.30	0.19	0.24	0.90	0.57	35.12	36.08	35.60
08/19	0.18	0.43	0.30	1.26	3.01	2.14	36.38	39.09	37.74
08/27	0.12	0.31	0.22	0.96	2.48	1.72	37.34	41.57	39.46
09/03	0.14	0.30	0.22	0.98	2.10	1.54	38.32	43.67	41.00
09/10	0.08	0.15	0.11	0.56	1.05	0.80	38.88	44.72	41.80
09/17	0.10	0.21	0.15	0.70	1.47	1.08	39.58	46.19	42.89
09/24	0.18	0.36	0.27	1.26	2.52	1.89	40.84	48.71	44.78
10/01	0.07	0.11	0.09	0.49	0.77	0.63	41.33	49.48	45.41
10/13	0.17	0.21	0.19	2.04	2.52	2.28	43.37	52.00	47.69
10/15	0.16	0.21	0.18	0.32	0.42	0.37	43.69	52.42	48.06
11/01	0.16	0.23	0.19	2.72	3.91	3.32	46.41	56.33	51.37
11/09	0.24	0.37	0.30	1.92	2.96	2.44	48.33	59.29	53.81
11/16	0.16	0.25	0.21	1.12	1.75	1.44	49.45	61.04	55.24
11/22	0.05	0.10	0.07	0.30	0.60	0.45	49.75	61.64	55.70
11/29	0.22	0.20	0.21	1.54	1.40	1.47	51.29	63.04	57.17
12/06	0.22	0.17	0.19	1.54	1.19	1.37	52.83	64.23	58.53
12/15	0.14	0.16	0.15	1.26	1.44	1.35	54.09	65.67	59.88
12/21	0.11	0.17	0.14	0.66	1.02	1.34	54.75	66.69	60.72

Table 17. Consumptive water use by cenizo irrigated when soil moisture tension was 0.30 bar at 30 cm depth (1982).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 4	Lys 12	Avg	Lys 4	Lys 12	Avg	Lys 4	Lys 12	Avg
06/04	0.35	0.30	0.32	10.85	9.30	10.08	10.85	9.30	10.08
06/11	0.07	0.12	0.09	0.49	0.84	0.66	11.34	10.14	10.74
06/24	0.95	0.93	0.94	12.35	12.09	12.22	23.69	22.23	22.96
07/09	0.23	0.11	0.17	3.45	1.65	2.55	27.14	23.88	25.51
09/14	0.54	0.40	0.47	2.70	2.00	2.35	29.84	25.88	27.86
07/19	0.30	0.91	0.60	1.50	4.55	3.02	31.34	30.43	30.89
07/21	0.43	0.43	0.43	0.86	0.86	0.86	32.20	31.29	31.75
07/28	0.26	0.47	0.36	1.82	3.29	2.56	34.02	34.58	34.30
08/04	0.19	0.27	0.23	1.33	1.89	1.61	35.35	36.47	35.91
08/09	0.22	0.28	0.25	1.10	0.84	1.47	36.45	37.87	37.16
08/12	0.18	0.25	0.21	0.54	0.25	0.39	36.99	38.62	37.81
08/19	0.24	0.46	0.35	0.24	0.46	0.35	38.67	41.84	40.26
08/27	0.63	0.58	0.60	0.63	0.58	0.60	43.71	46.48	45.10
09/03	0.35	0.62	0.48	2.45	0.62	1.53	46.16	50.82	48.49
09/10	0.56	0.48	0.52	3.92	0.48	2.20	50.08	54.18	52.13
09/17	0.33	0.58	0.45	2.31	4.06	3.18	52.39	58.24	55.32
09/24	0.54	0.50	0.52	3.78	3.50	3.64	56.17	61.74	58.96
10/01	0.35	0.47	0.41	2.45	3.29	2.87	58.62	65.03	61.83
10/13	0.44	0.54	0.49	5.28	6.48	5.88	63.90	71.51	67.71
10/15	0.34	0.40	0.37	0.68	0.80	0.74	64.58	72.31	68.45
11/01	0.26	0.35	0.30	4.42	5.95	5.18	69.00	78.26	73.63
11/09	0.43	0.38	0.40	3.44	3.04	3.24	72.44	81.30	76.87
11/16	0.22	0.29	0.25	1.54	2.03	1.78	73.98	83.33	78.66
11/22	0.09	0.15	0.12	0.54	0.90	0.72	74.52	84.23	79.38
11/29	0.15	0.28	0.21	1.05	1.96	1.50	75.57	86.19	80.88
12/06	0.15	0.28	0.21	1.05	1.96	1.50	76.62	88.15	82.39
12/15	0.11	0.16	0.13	0.99	1.44	1.21	77.61	89.59	83.60
12/21	0.11	0.17	0.14	0.66	1.02	0.84	78.27	90.61	84.44

Table 18. Consumptive water use by cenizo irrigated when soil moisture tension was 0.40 bar at 76 cm depth (1982).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 3	Lys 8	Avg	Lys 3	Lys 8	Avg	Lys 3	Lys 8	Avg
06/04	0.36	0.43	0.39	11.16	13.33	12.25	11.16	13.33	12.25
06/11	0.65	0.89	0.77	4.55	6.23	5.39	15.71	19.56	17.64
06/24	0.96	1.18	1.07	12.48	15.34	13.91	28.19	34.90	31.55
07/09	0.41	0.67	0.54	6.15	10.05	8.10	34.34	44.95	39.65
07/14	0.48	0.79	0.63	2.40	3.95	3.17	36.74	48.90	42.82
07/19	0.45	0.49	0.47	2.25	2.45	2.35	38.99	51.35	45.17
07/21	0.48	0.72	0.60	0.96	1.44	1.20	39.95	52.79	46.37
07/28	0.52	0.78	0.65	3.64	5.46	4.55	43.59	58.25	50.92
08/04	0.62	0.96	0.79	4.34	6.72	5.53	47.93	64.97	56.45
08/09	0.84	1.15	1.00	4.20	5.75	4.97	52.13	70.72	61.43
08/12	0.60	1.11	0.85	1.80	1.11	1.45	53.93	74.05	63.99
08/19	0.92	1.39	1.16	6.44	9.73	8.08	60.37	83.78	72.08
08/27	0.93	1.26	1.09	7.44	10.08	8.76	67.81	93.86	80.84
09/03	0.95	1.32	1.13	6.65	9.24	7.94	74.46	103.10	88.78
09/10	0.85	1.20	1.02	5.95	8.40	7.18	80.41	111.50	95.96
09/17	0.87	1.04	0.95	6.09	7.28	6.68	86.50	118.78	102.64
09/24	0.73	0.95	0.48	5.11	6.65	5.88	91.61	125.43	108.52
10/01	0.70	0.80	0.75	4.90	5.60	5.25	96.51	131.03	113.77
10/13	0.60	0.82	0.71	7.20	9.84	8.52	103.71	140.87	122.29
10/15	0.55	0.67	0.61	1.10	1.34	1.22	104.81	142.21	123.51
11/01	0.41	0.32	0.36	6.97	5.44	6.20	111.78	147.65	129.72
11/09	0.31	0.41	0.36	2.48	3.28	2.88	114.26	150.93	132.60
11/16	0.19	0.30	0.24	1.33	2.10	1.71	115.59	153.03	134.31
11/22	0.05	0.18	0.11	0.30	1.08	0.69	115.89	154.11	135.00
11/29	0.17	0.08	0.12	1.19	0.56	0.87	117.08	154.67	135.88
12/06	0.20	0.30	0.25	1.40	2.10	1.75	118.48	156.77	137.63
12/15	0.07	0.07	0.07	0.63	0.63	0.63	119.11	157.40	138.26
12/21	0.10	0.13	0.11	0.60	0.78	0.69	119.71	158.18	138.95

Table 19. Consumptive water use by boxwood irrigated when soil moisture tension was 0.30 bar at 30 cm depth (1982)

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 6	Lys 7	Avg	Lys 6	Lys 7	Avg	Lys 6	Lys 7	Avg
06/04	0.32	0.55	0.44	9.92	17.05	13.49	9.92	17.05	13.49
06/11	0.60	0.62	0.61	4.20	4.34	4.27	14.12	21.39	17.76
06/24	0.93	0.93	0.93	12.09	12.09	12.09	26.21	33.48	29.85
07/09	0.31	0.29	0.30	4.65	4.35	4.50	30.86	37.83	34.35
07/14	0.33	0.32	0.32	1.65	1.60	1.62	32.51	39.43	35.97
07/19	0.18	0.19	0.18	0.90	0.95	0.92	33.41	40.38	36.90
07/21	0.31	0.42	0.36	0.62	0.84	0.73	34.03	41.22	37.63
07/28	0.24	0.22	0.23	1.68	1.54	1.61	36.71	42.76	39.24
08/04	0.16	0.27	0.22	1.12	1.89	1.50	36.83	44.65	40.74
08/09	0.11	0.20	0.16	0.55	1.00	0.78	37.38	45.65	41.52
08/12	0.38	0.36	0.37	1.14	1.04	1.09	38.52	46.73	42.63
08/19	0.26	0.36	0.31	1.82	2.52	2.17	40.34	49.25	44.80
08/27	0.28	0.36	0.32	2.24	2.88	2.56	42.58	52.13	47.36
09/03	0.26	0.37	0.31	1.82	2.59	2.20	44.40	54.72	49.56
09/10	0.27	0.30	0.28	1.89	2.10	2.00	46.29	56.82	51.56
09/17	0.24	0.36	0.30	1.68	2.52	2.10	4917.97	59.34	53.66
09/24	0.35	0.33	0.34	2.45	2.31	2.38	50.42	61.65	56.04
10/01	0.14	0.14	0.14	0.98	0.98	0.98	51.40	62.63	57.02
10/13	0.24	0.36	0.30	2.88	4.32	3.60	54.28	66.95	60.62
10/15	0.26	0.27	0.26	0.52	0.54	0.53	54.80	67.49	61.15
11/01	0.20	0.22	0.21	3.40	3.74	3.57	58.20	71.23	64.72
11/09	0.35	0.32	0.33	2.80	2.56	2.68	61.00	73.79	67.40
11/16	0.24	0.26	0.25	1.68	1.82	1.75	62.68	75.61	69.15
11/22	0.08	0.08	0.08	0.48	0.48	0.48	63.16	76.09	69.63
11/29	0.23	0.27	0.25	1.61	1.89	1.75	64.77	77.98	71.38
12/06	0.26	0.20	0.23	1.82	1.40	1.61	66.59	79.38	72.99
12/15	0.14	0.16	0.15	1.26	1.44	1.35	67.85	80.82	74.34
12/21	0.17	0.13	0.15	1.02	0.78	0.90	68.87	81.60	75.24

Table 20. Consumptive water use by boxwood irrigated when soil moisture tension was 0.40 bar at 76 cm depth (1982).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 2	Lys 11	Avg	Lys 2	Lys 11	Avg	Lys 2	Lys 11	Avg
06/04	0.32	0.37	0.34	9.92	11.47	10.70	9.92	11.47	10.70
06/11	0.65	0.64	0.64	4.55	4.48	4.52	14.47	15.95	15.21
06/24	0.95	0.92	0.94	12.35	11.96	12.16	26.82	27.91	27.37
07/09	0.30	0.32	0.31	4.50	4.80	4.65	31.32	32.71	32.02
07/14	0.65	0.31	0.48	3.25	1.55	2.40	34.57	34.26	34.42
07/19	0.19	0.19	0.19	0.95	0.95	0.95	35.52	35.21	35.37
07/21	0.54	0.31	0.42	1.08	0.62	0.85	36.60	35.83	36.22
07/28	0.27	0.25	0.26	1.89	1.75	1.82	38.49	37.58	38.04
08/04	0.16	0.13	0.14	1.12	0.91	1.02	39.61	38.49	39.05
08/09	0.13	0.15	0.14	0.65	0.75	0.70	40.26	39.24	39.75
08/12	0.13	0.13	0.13	0.39	0.39	0.39	40.65	39.63	40.14
08/19	0.17	0.14	0.16	1.19	0.98	1.08	41.84	40.61	41.23
08/27	0.10	0.09	0.10	0.80	0.72	0.76	42.64	41.33	41.99
09/03	0.14	0.15	0.15	0.98	1.05	1.02	43.62	42.38	43.00
09/10	0.04	0.04	0.04	0.28	0.28	0.28	43.90	42.66	43.28
09/17	0.08	0.08	0.08	0.56	0.56	0.56	44.46	43.22	43.84
09/24	0.18	0.15	0.17	1.26	1.05	1.16	45.72	44.27	45.00
10/01	0.09	0.07	0.08	0.63	0.49	0.56	46.35	44.81	45.58
10/13	0.15	0.14	0.15	1.80	1.68	1.74	48.15	46.49	47.32
10/15	0.20	0.18	0.19	0.40	0.36	0.38	48.55	46.85	47.70
11/01	0.17	0.16	0.17	2.89	2.72	2.81	51.44	49.57	50.50
11/09	0.23	0.32	0.28	1.84	2.56	2.20	53.28	52.13	52.70
11/16	0.20	0.20	0.20	1.40	1.40	1.40	54.68	53.53	54.10
11/22	0.06	0.09	0.08	0.36	0.54	0.45	55.04	54.07	54.55
11/29	0.20	0.20	0.20	1.40	1.40	1.40	56.44	55.47	55.95
12/06	0.45	0.23	0.34	3.15	1.61	2.38	59.59	57.08	58.33
12/15	0.13	0.13	0.13	1.17	1.17	1.17	60.76	58.25	59.50
12/21	0.17	0.20	0.19	1.02	1.20	1.11	61.78	59.45	60.61

was between 20 and 30 cm for all shrubs (except the cenizo using 41.8 cm) regardless of the water level or species (Tables 21-26). The relationship between plant size and water use such as that found in 1982 was not obtained from May to July 1983.

Water Use by Container Grown Plants

Water use studies with container grown cenizo and Indian Hawthorn indicated a much faster growth rate of cenizo than Indian Hawthorn (Fig. 8). During a five month period (May 1981 to September 1981) irrigating Indian Hawthorn at 0.6 bar soil moisture tension resulted in a 71% decrease in plant weight compared to plants irrigated at 0.2 bar. Reduction in size of cenizo was 38% at the same irrigation treatments. Indian Hawthorn in containers irrigated at 3 bar soil moisture tension were dead at the end of the study period. Cenizo irrigated at 3 bar tension were not dead but growth was reduced by 80% compared to the 0.2 bar irrigation level.

Cenizo and boxwood grown in 15 cm pots (2/3 Austin silty clay 1/3 perlite) under greenhouse conditions and irrigated when soil moisture tension was 0.15 bar and 0.6 bar exhibited different growth characteristics. The study was initiated with sufficient plants to cut two plants at ground level and obtain plant dry weights at approximately monthly intervals. Dry weight of cenizo increased from 3 grams to about 17 grams after 5 months growth period. Soil moisture level did not influence growth rate of cenizo. A paired t test however indicated that boxwood growth was less when irrigated at 0.6 bar than when irrigated at 0.15 bar tension. Dry weight of boxwood increased from 2 grams at initiation of the study to 5 grams at the

Table 21. Consumptive water use by Texas barberry irrigated when soil moisture tension was 0.25 bar at 76 cm depth (1983).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 1	Lys 10	Avg	Lys 1	Lys 10	Avg	Lys 1	Lys 10	Avg
01/11	.11	.09	.10	2.31	1.89	2.10	2.31	1.89	2.10
02/03	.11	.11	.11	2.53	2.53	2.53	4.84	4.42	4.63
03/14	.12	.12	.12	4.68	4.68	4.68	9.52	9.10	9.31
03/29	.15	.17	.16	2.25	2.55	2.40	11.77	11.65	11.71
04/11	.15	.21	.18	1.95	2.73	2.34	13.72	14.38	14.05
04/18	.23	.18	.21	1.61	1.26	1.44	15.33	15.64	15.49
04/25	.16	.11	.14	1.12	.77	.95	16.45	16.41	16.43
05/09	.30	.26	.28	4.20	3.64	3.92	20.65	20.05	20.35
05/16	.21	.20	.21	1.47	1.40	1.44	22.12	21.45	21.79
05/26	.54	.52	.53	5.40	5.20	5.30	27.52	26.65	27.09
06/03	.37	.38	.38	2.96	3.04	3.00	30.48	29.69	30.09
06/09	.41	.38	.40	2.46	2.28	2.37	32.94	31.97	32.46
06/16	.49	.46	.48	3.43	3.22	3.33	36.37	35.19	35.78
06/23	.43	.36	.40	3.01	2.52	2.77	39.38	37.71	38.55
06/30	.42	.53	.48	2.94	3.71	3.33	42.32	41.42	41.87
07/07	.47	.49	.48	3.29	3.43	3.36	45.61	44.85	45.23
07/15	.42	.36	.39	3.36	2.88	3.12	48.97	47.73	48.35

Table 22. Consumptive water use by Texas barberry irrigated when soil moisture tension was 0.75 bar at 76 cm depth (1983).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 5	Lys 9	Avg	Lys 5	Lys 9	Avg	Lys 5	Lys 9	Avg
01/11	.11	.11	.11	2.31	2.31	2.31	2.31	2.31	2.31
02/03	.08	.09	.09	1.84	2.07	1.96	4.15	4.38	4.27
03/14	.10	.13	.12	3.90	5.07	4.49	8.05	9.45	8.75
03/29	.16	.18	.17	2.40	2.70	2.55	10.45	12.15	11.30
04/11	.15	.13	.14	1.95	1.69	1.82	12.40	13.84	13.12
04/18	.13	.11	.12	.91	.77	.84	13.31	14.61	13.96
04/25	.13	.10	.12	.91	.70	.81	14.22	15.31	14.77
05/09	.20	.15	.18	2.80	2.10	2.45	17.02	17.41	17.22
05/16	.20	.17	.19	1.40	1.19	1.30	18.42	18.60	18.51
05/26	.46	.40	.43	4.60	4.00	4.30	23.02	22.60	22.81
06/03	.27	.29	.28	2.16	2.32	2.24	25.18	24.92	25.05
06/09	.34	.31	.33	2.04	1.86	1.95	27.22	26.78	27.00
06/16	.41	.41	.41	2.87	2.87	2.87	30.09	29.65	29.87
06/23	.34	.27	.31	2.38	1.89	2.14	32.47	31.54	32.01
06/30	.42	.42	.42	2.94	2.94	2.94	35.41	34.48	34.95
07/07	.49	.57	.53	3.43	3.99	3.71	38.84	38.47	38.66
07/15	.36	.33	.35	2.88	2.64	2.76	41.72	41.11	41.42

Table 23. Consumptive water use by cenizo irrigated when soil moisture tension was 0.25 bar at 76 cm depth (1983).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 4	Lys 12	Avg	Lys 4	Lys 12	Avg	Lys 4	Lys 12	Avg
01/11	.09	.12	.11	1.89	2.52	2.21	1.89	2.52	2.21
02/03	.10	.10	.10	2.30	2.30	2.30	4.19	4.82	4.51
03/14	.17	.12	.15	6.63	4.68	5.66	10.82	9.50	10.16
03/29	.17	.17	.17	2.55	2.55	2.55	13.37	12.05	12.71
04/11	.23	.19	.21	2.99	2.47	2.73	16.36	14.52	15.44
04/18	.20	.22	.21	1.40	1.54	1.47	17.76	16.06	16.91
04/25	.10	.20	.15	.70	1.40	1.05	18.46	17.46	17.96
05/09	.24	.35	.30	3.36	4.90	4.13	21.82	22.36	22.09
05/16	.25	.32	.29	1.75	2.24	2.00	23.57	24.60	24.09
05/26	.44	.71	.58	4.40	7.10	5.75	27.97	31.70	29.84
06/03	.32	.55	.44	2.56	4.40	3.48	30.53	36.10	33.32
06/09	.39	.69	.54	2.34	4.14	3.24	32.87	40.24	36.56
06/16	.48	.84	.66	3.36	5.88	4.62	36.23	46.12	41.18
06/23	.41	.78	.60	2.87	5.46	4.16	39.10	51.58	45.34
06/30	.43	.64	.54	3.01	4.48	3.75	42.11	56.06	49.09
07/07	.36	.63	.50	2.52	4.41	3.47	44.63	60.47	52.55
07/15	.47	.46	.47	3.76	3.68	3.72	48.39	64.15	56.27

Table 24. Consumptive water use by cenizo irrigated when soil moisture tension was 0.75 bar at 76 cm depth (1983).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 3	Lys 8	Avg	Lys 3	Lys 8	Avg	Lys 3	Lys 8	Avg
01/11	.08	.13	.11	1.68	2.73	2.21	1.68	2.73	2.21
02/03	.09	.09	.09	2.07	2.07	2.07	3.75	4.80	4.28
03/14	.10	.12	.11	3.90	4.68	4.29	7.65	9.48	8.57
03/29	.14	.12	.13	2.10	1.80	1.95	9.75	11.28	10.52
04/11	.17	.19	.18	2.21	2.47	2.34	11.96	13.75	12.86
04/18	.12	.15	.14	.84	1.05	.95	12.80	14.80	13.80
04/25	.08	.10	.09	.56	.70	.63	13.36	15.50	14.43
05/09	.16	.26	.21	2.24	3.64	2.94	15.60	19.14	17.37
05/16	.15	.27	.21	1.05	1.89	1.47	16.65	21.03	18.84
05/26	.18	.43	.31	1.80	4.30	3.05	18.45	25.33	21.89
06/03	.31	.46	.39	2.48	3.68	3.08	20.93	29.01	24.97
06/09	.31	.54	.43	1.86	3.24	2.55	22.79	32.25	27.52
06/16	.36	.56	.46	2.52	3.92	3.22	25.31	36.17	30.74
06/23	.30	.38	.34	2.10	2.66	2.38	27.41	38.83	33.12
06/30	.40	.41	.41	2.80	2.87	2.84	30.21	41.70	35.96
07/07	.27	.43	.35	1.89	3.01	2.45	32.10	44.71	38.41
07/15	.44	.46	.45	3.52	3.68	3.60	35.62	48.39	42.01

Table 25. Consumptive water use by boxwood irrigated when soil moisture tension was 0.25 bar at 76 cm depth (1983).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 6	Lys 7	Avg	Lys 6	Lys 7	Avg	Lys 6	Lys 7	Avg
01/11	.11	.12	.12	2.31	2.52	2.42	2.31	2.52	2.42
02/03	.10	.11	.11	2.30	2.53	2.42	4.61	5.05	4.83
03/14	.14	.14	.14	5.46	5.46	5.46	10.07	10.51	10.29
03/29	.21	.20	.21	3.15	3.00	3.08	13.22	13.51	13.37
04/11	.20	.20	.20	2.60	2.60	2.60	15.82	16.11	15.97
04/18	.21	.21	.21	1.47	1.47	1.47	17.29	17.58	17.44
04/25	.17	.14	.16	1.19	.98	1.09	18.48	18.56	18.52
05/09	.19	.20	.20	2.66	2.80	2.73	21.14	21.36	21.25
05/16	.18	.19	.19	1.26	1.33	1.30	22.40	22.69	22.55
05/26	.41	.46	.44	4.10	4.60	4.35	26.50	27.29	26.90
06/03	.29	.38	.34	2.32	3.04	2.68	28.82	30.33	29.58
06/09	.34	.33	.34	2.04	1.98	2.01	30.86	32.31	31.59
06/16	.38	.39	.39	2.66	2.73	2.70	33.52	35.04	34.28
06/23	.24	.30	.27	1.68	2.10	1.89	35.20	37.14	36.17
06/30	.36	.35	.36	2.52	2.45	2.49	37.72	39.59	38.66
07/07	.30	.29	.30	2.10	2.03	2.07	39.82	41.62	40.72
07/15	.33	.35	.34	2.64	2.80	2.72	42.46	44.42	43.44

Table 26. Consumptive water use by boxwood irrigated when soil moisture tension was 0.75 bar at 76 cm depth (1983).

Date	cm Water Use/Day			cm Water Use/Period			Cumulative Use (cm)		
	Lys 2	Lys 11	Avg	Lys 2	Lys 11	Avg	Lys 2	Lys 11	Avg
01/11	.11	.12	.12	2.31	2.52	2.42	2.31	2.52	2.42
02/03	.10	.09	.10	2.30	2.07	2.18	4.61	4.59	4.60
03/14	.13	.13	.13	5.07	5.07	5.07	9.68	9.66	9.67
03/29	.17	.18	.18	2.55	2.70	2.63	12.23	12.36	12.30
04/11	.18	.18	.18	2.34	2.34	2.34	14.57	14.70	14.64
04/18	.17	.16	.17	1.19	1.12	1.16	15.76	15.82	15.79
04/25	.12	.12	.12	.84	.84	.84	16.60	16.66	16.63
05/09	.20	.17	.19	2.80	2.38	2.59	19.40	19.04	19.22
05/16	.18	.18	.18	1.26	1.26	1.26	20.66	20.30	20.48
05/26	.37	.41	.39	3.70	4.10	3.90	24.36	24.40	24.38
06/03	.26	.29	.28	2.08	2.32	2.20	26.44	26.72	26.58
06/09	.31	.30	.31	1.86	1.80	1.83	28.30	28.52	28.41
06/16	.41	.36	.39	2.87	2.52	2.69	31.17	31.04	31.11
06/23	.25	.23	.24	1.75	1.61	1.68	32.92	32.65	32.79
06/30	.35	.34	.35	2.45	2.38	2.42	35.37	35.03	35.20
07/07	.28	.28	.28	1.96	1.96	1.96	37.33	36.99	37.16
07/15	.33	.32	.33	2.64	2.56	2.60	39.79	39.55	39.76

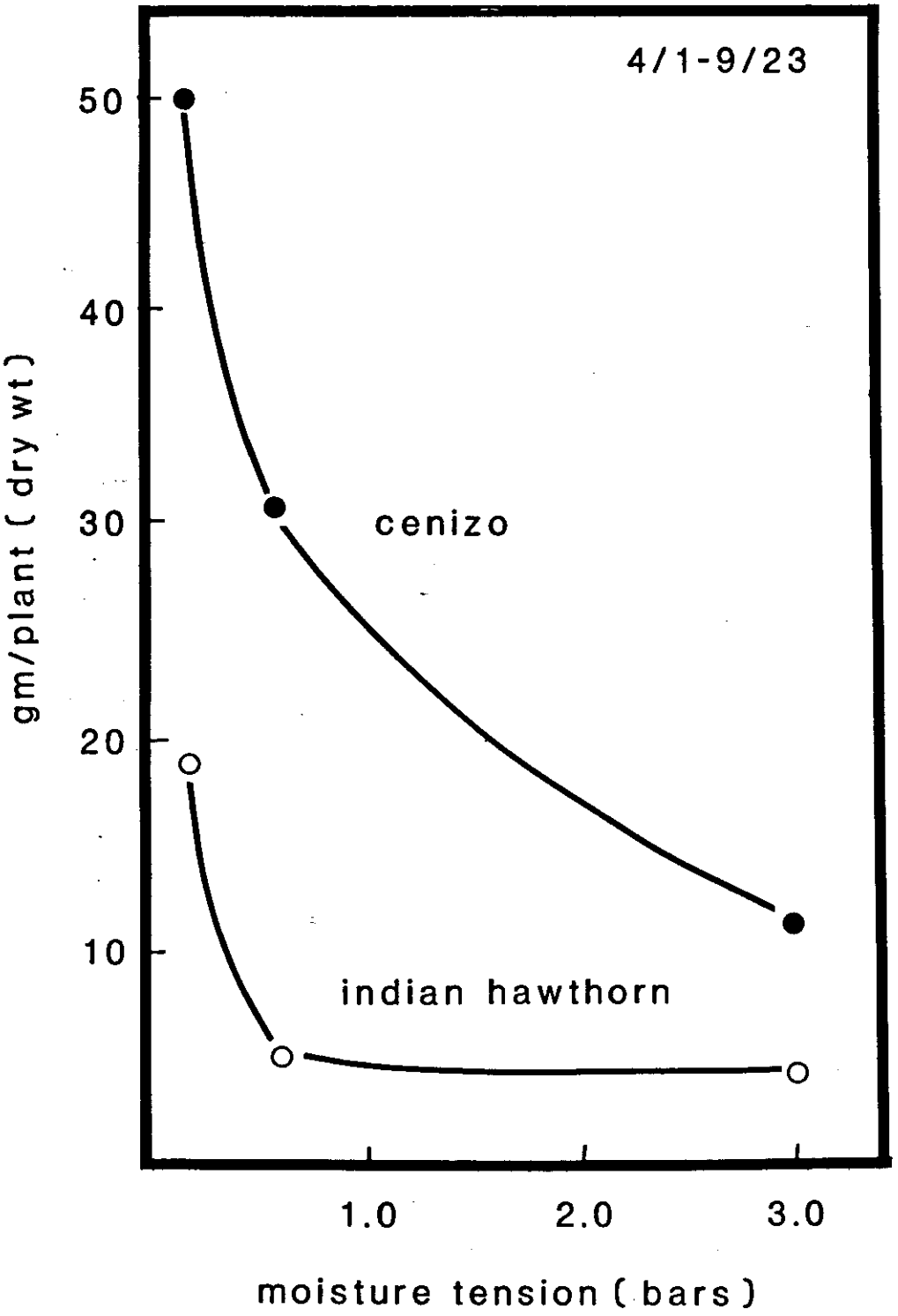

Fig. 8. Relationship between soil moisture tension and plant dry weight of cenizo and Indian Hawthorn.

end of the growth period when irrigated at 0.15 bar tension. Growth was about one-half as much when irrigated at 0.6 bar moisture tension (Fig. 9).

In additional studies, cenizo and boxwood were irrigated at 0.05, 0.15, 0.3, and 0.6 bar moisture tension as indicated by tensiometers. Water use was determined by subtracting drainage volume from volume applied to each pot. The difference was assumed to be water use because evaporation was retarded by a 4 cm layer of perlite. Plants were cut at soil level after 4 months growth and dry weights determined. Cenizo required about 750 ml of water per gram of plant produced but boxwood required about 1500 ml/gram of plant produced (Fig. 10). Soil moisture tension did not significantly (0.05 level) influence the amount of water required per gram of dry matter produced for either plant species. Water use was determined for each plant in the study the day before cutting and water use/day/gram of plant material determined (full sun, 25-37°C air temp). Water use/gram of plant material was greatest at low moisture tension (0.05 -0.15 bar) but decreased as soil moisture tension increased (Fig. 11). Water use was 8 and 11 ml/gm/day for cenizo and boxwood, respectively, at 0.15 bar tension but decreased to 4.2 and 7 ml/gm at 0.6 bar tension.

Water use by various sized container grown Texas madrone was determined when grown in 1:1 peat:perlite media. Leaf area of plants was determined with a Licor leaf area meter. Daily water use by madrone was found to be a function of leaf area as indicated in Fig. 12. Water use was 41 ml/day for plants with 100 cm^2 leaf area but increased to 251 ml day if leaf area was 1000 cm^2. These data, as

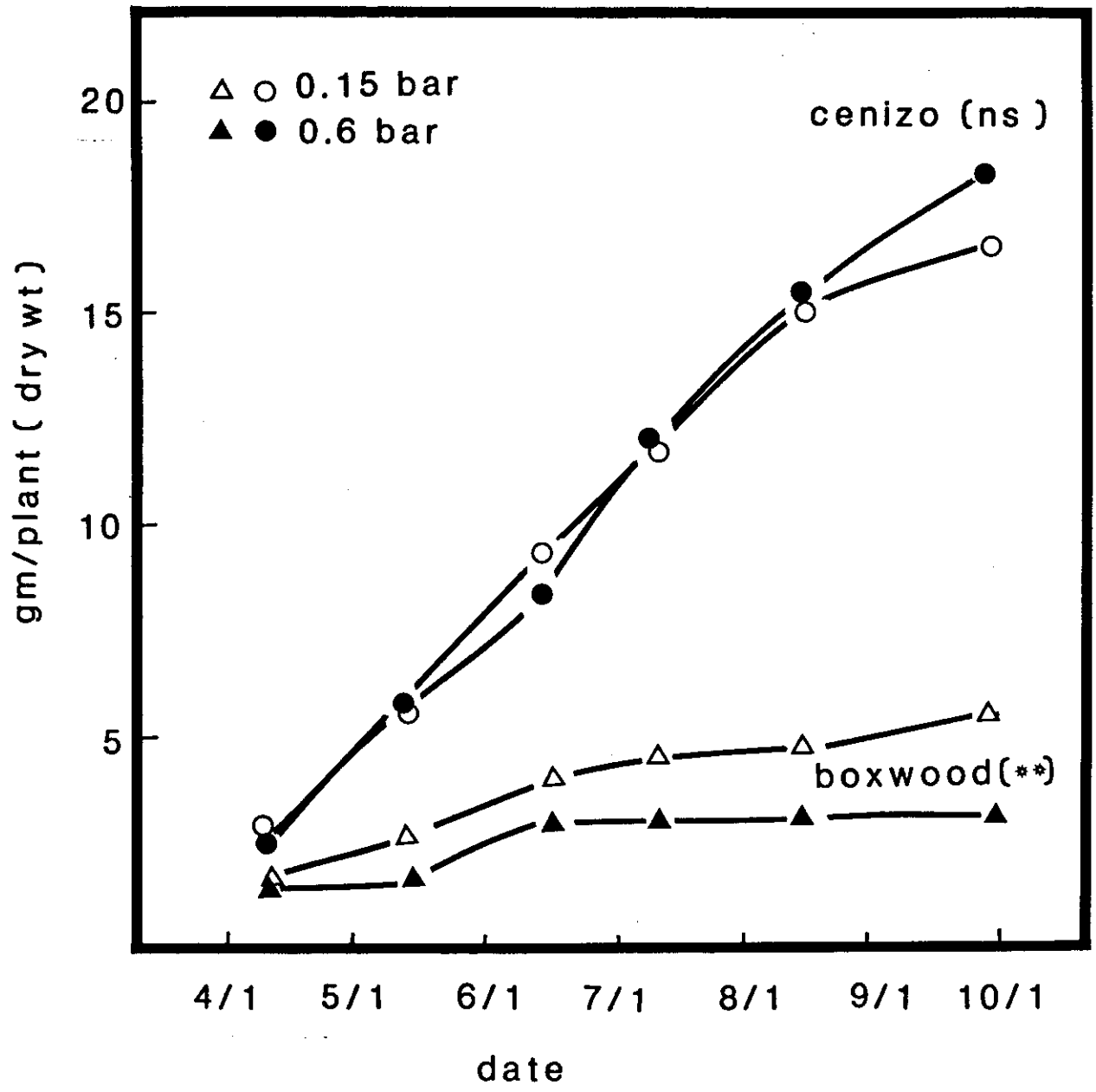

Fig. 9. Growth rate of boxwood and cenizo at two soil moisture tensions.

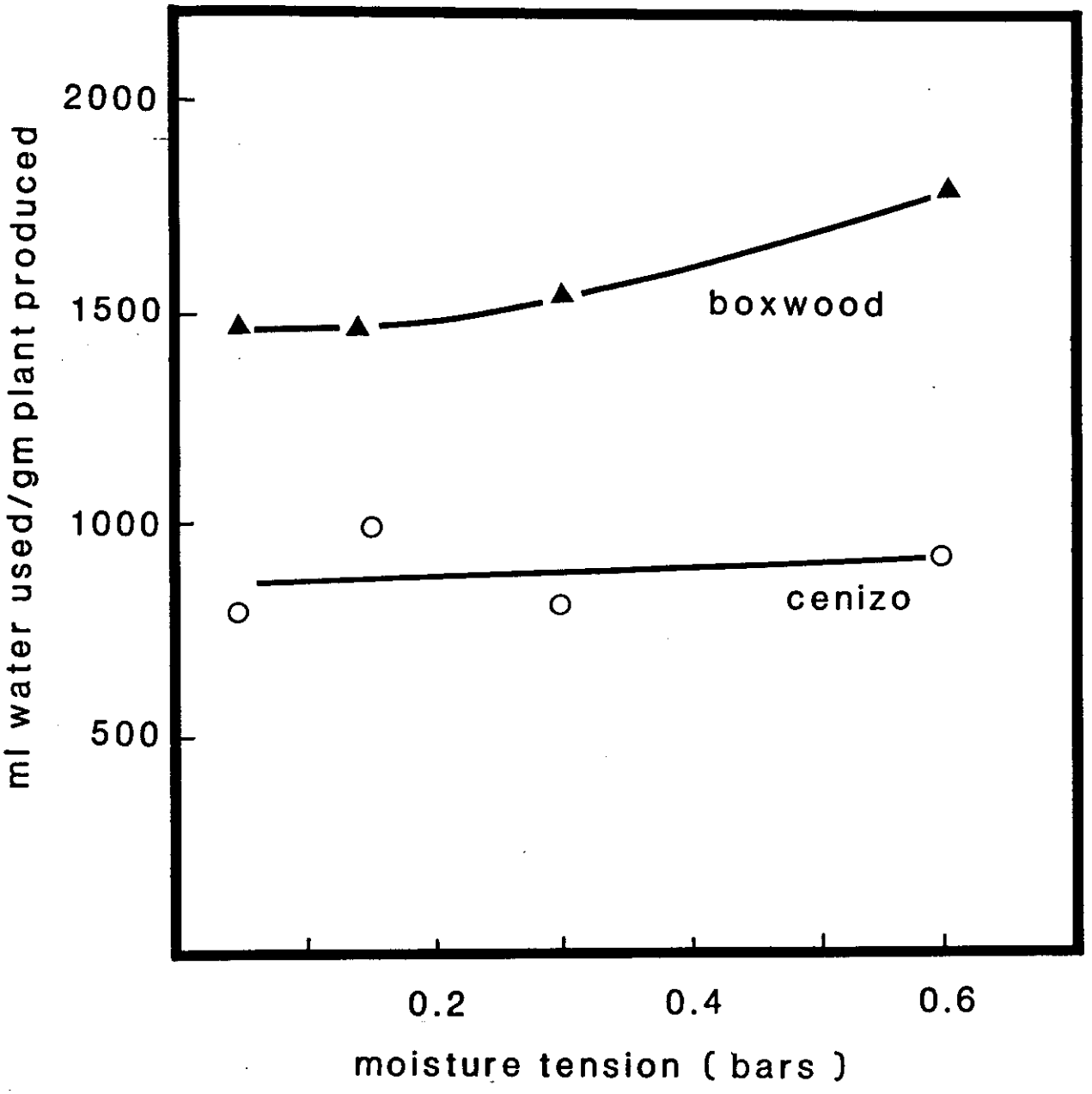

Fig. 10. Water use by cenizo and boxwood as influenced by soil moisture tension.

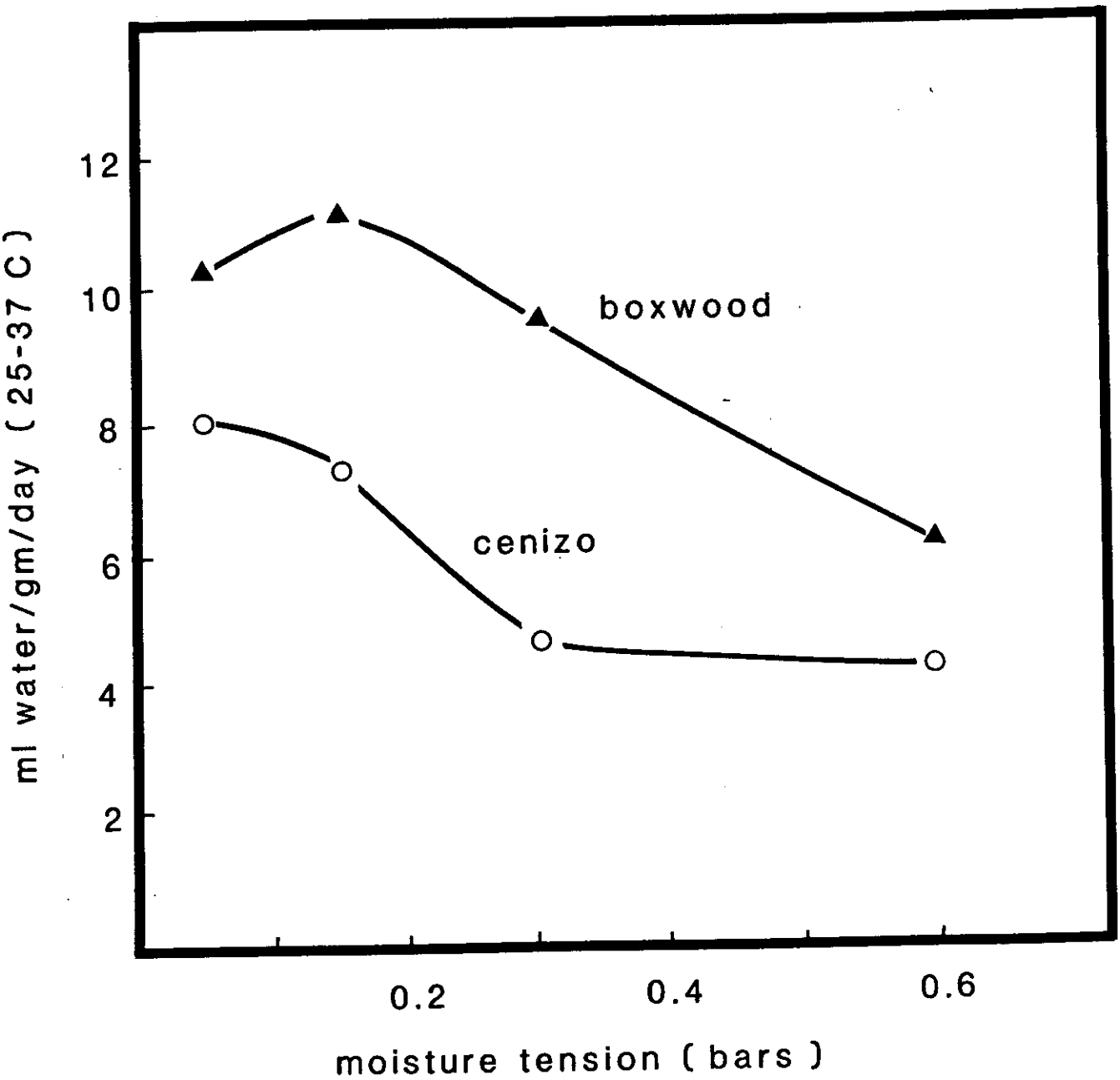

Fig. 11. Daily water use by cenizo and boxwood as influenced by soil moisture tension.

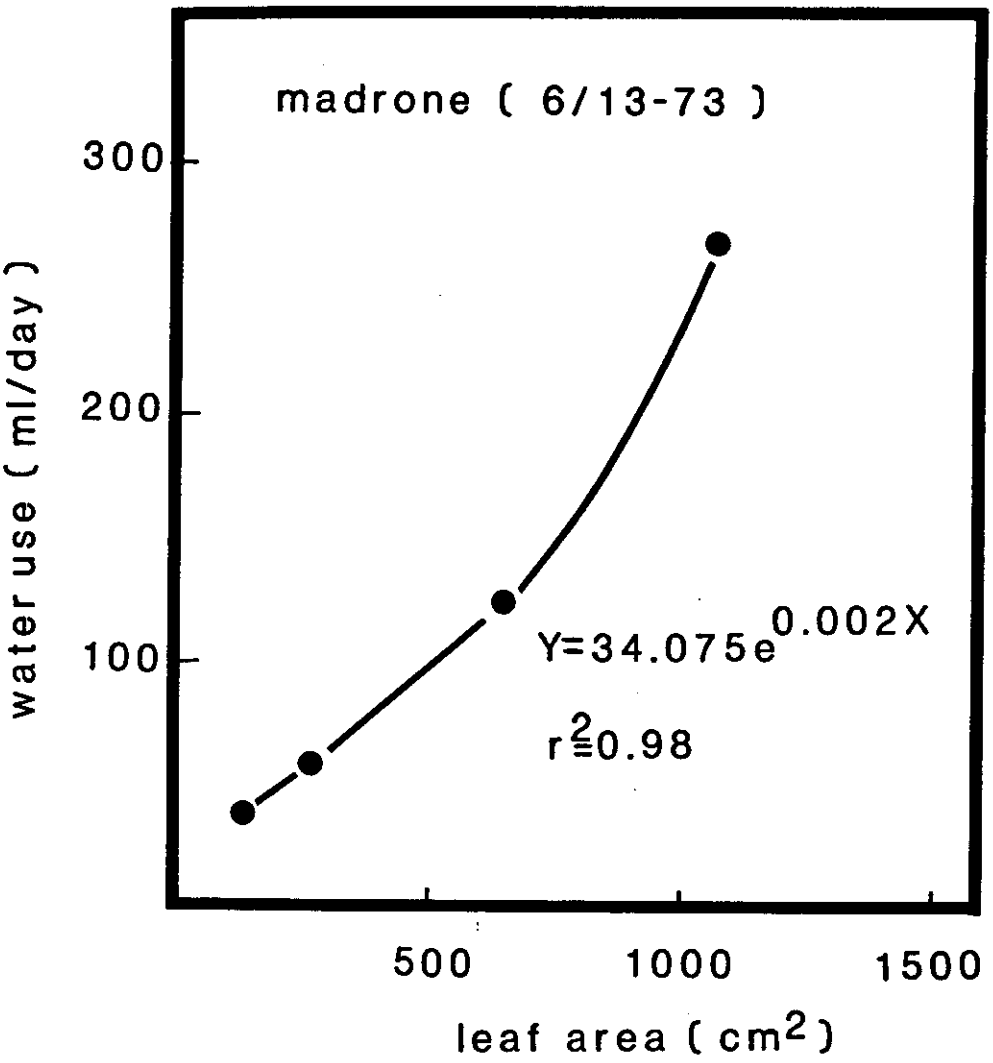

Fig. 12. Relationship between leaf area and daily water use by container grown Texas madrone (Arbutus xalapensis).

well as 1982 field lysimeter data, suggest that plant size is one of the most important factors in water requirement of shrubs.

Water use by four species of container grown (2/3 soil - 1/3 perlite) native shrubs, irrigated when 25, 50, and 75% of available moisture was depleted, decreased sharply from August to November. Texas barberry used less water than winterfat, evergreen sumac, and star leaf Mexican orange when irrigated at 25% available water depletion. Water use ranged from 130 ml/day/plant (winterfat - 25% of water depleted) in August to 20 ml/day/plant (Texas barberry - 75% of water depleted) in November (Fig. 13-16). These data suggest that Texas barberry would be a plant adaptable to water conserving landscapes.

Transpiration

A limited amount of transpiration data were collected with a porometer during August and September 1982. Although transpiration ranges were obtained, it was determined that uncontrollable factors, such as wind, humidity, radiation, soil moisture and temperature exerted so much influence on transpiration that it was beyond the scope of this study to obtain these data. The transpiration data obtained for 5 species of native plants are given in Appendix Table 4.

Daily Lysimeter Weights

Daily water use values for shrubs and turfgrasses were obtained by daily weighing of the lysimeters from August 10, 1982 through August 20, 1982. Although the data obtained appeared to be similar to the daily use calculated from weekly weighings, the daily changes were so small that errors in weighing could have occurred. The accuracy of

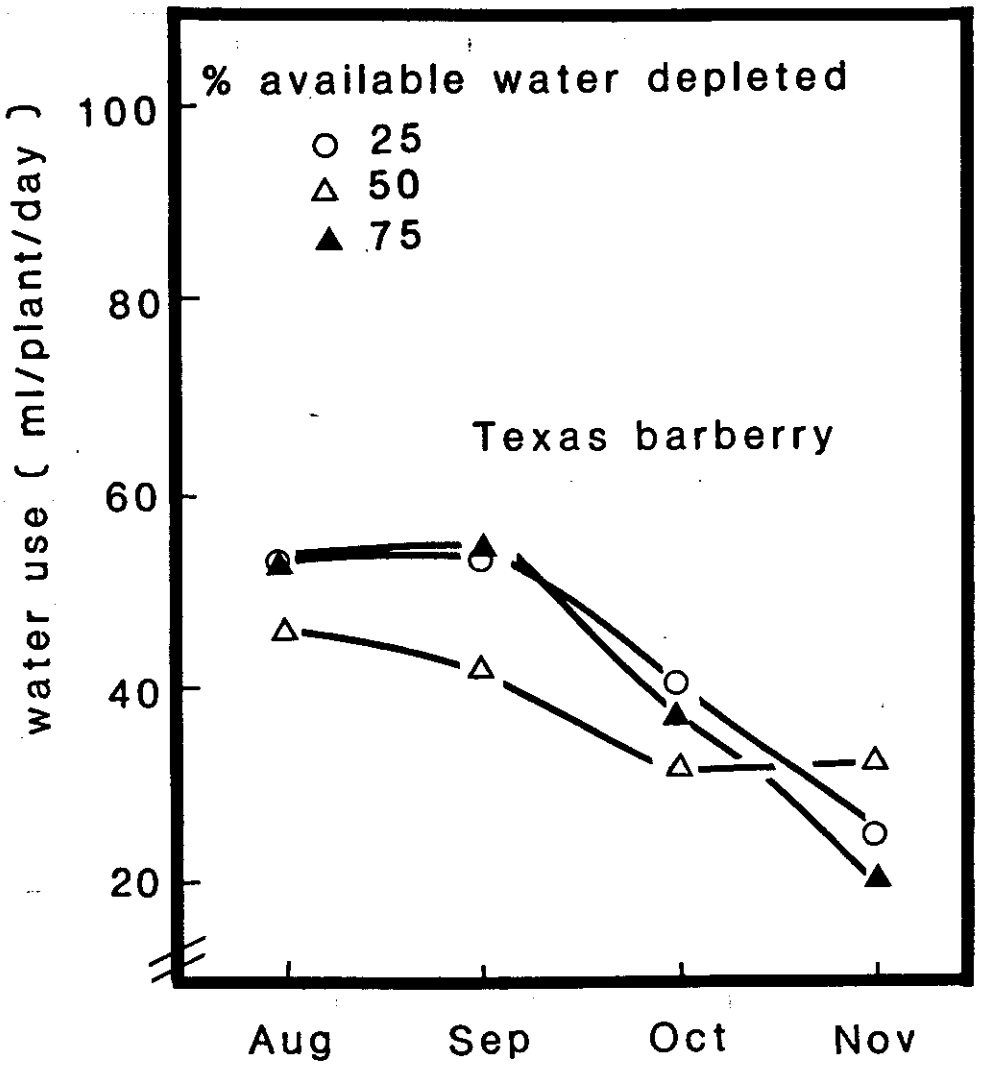

Fig. 13. Daily water use by Texas barberry (Berberis swaseyi) at 3 moisture levels during a 4 month period.

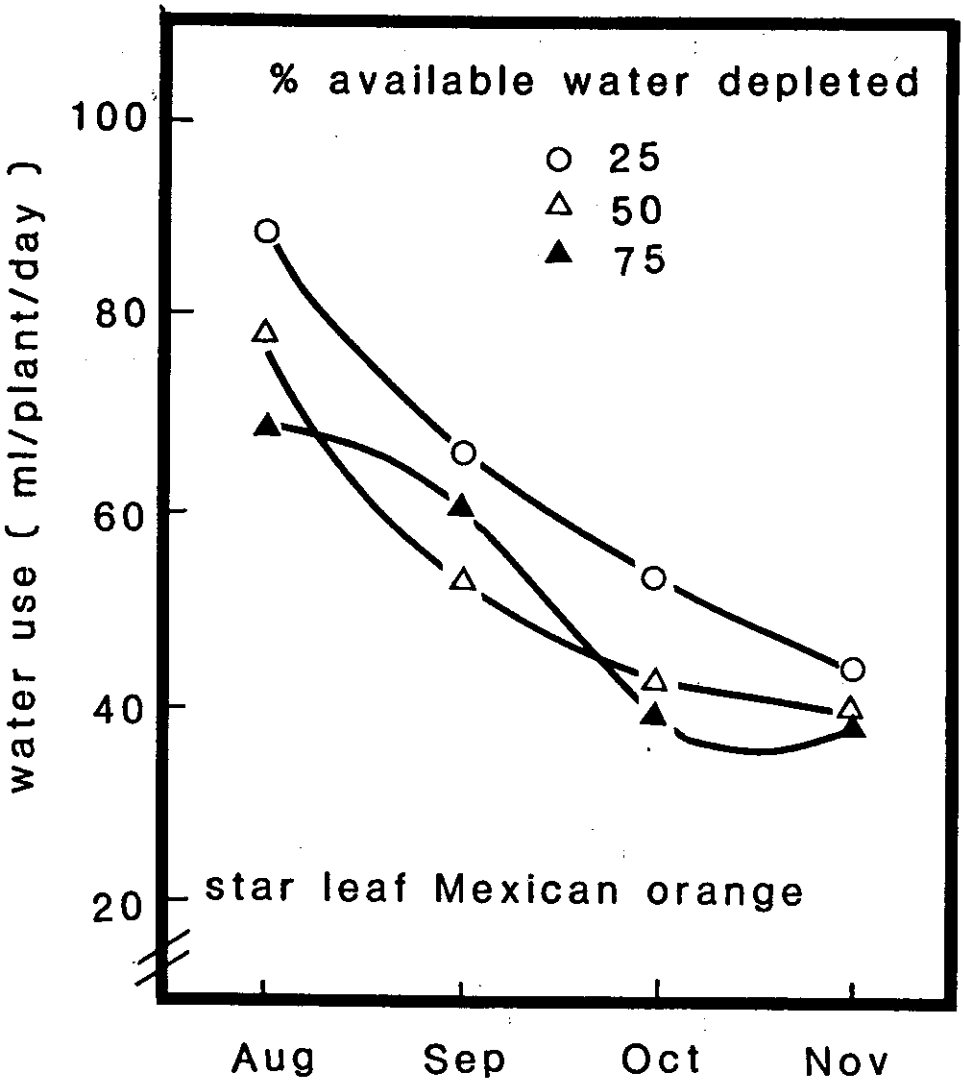

Fig. 14. Daily water use by star leaf Mexican orange (Choisya dumosa) at 3 moisture levels during a 4 month period.

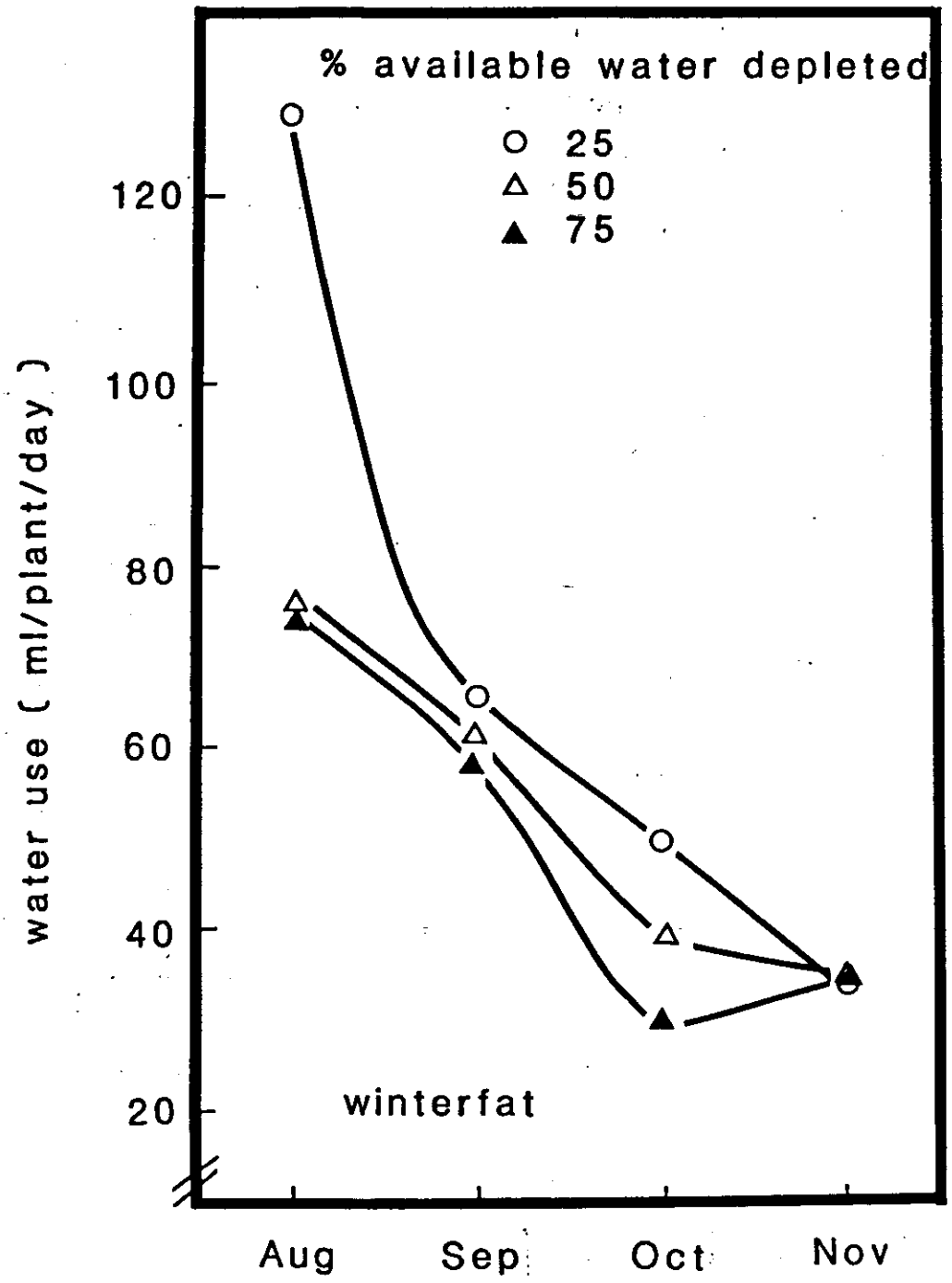

Fig. 15. Daily water use by winterfat (Eurotia lanata) at 3 moisture levels during a 4 month period.

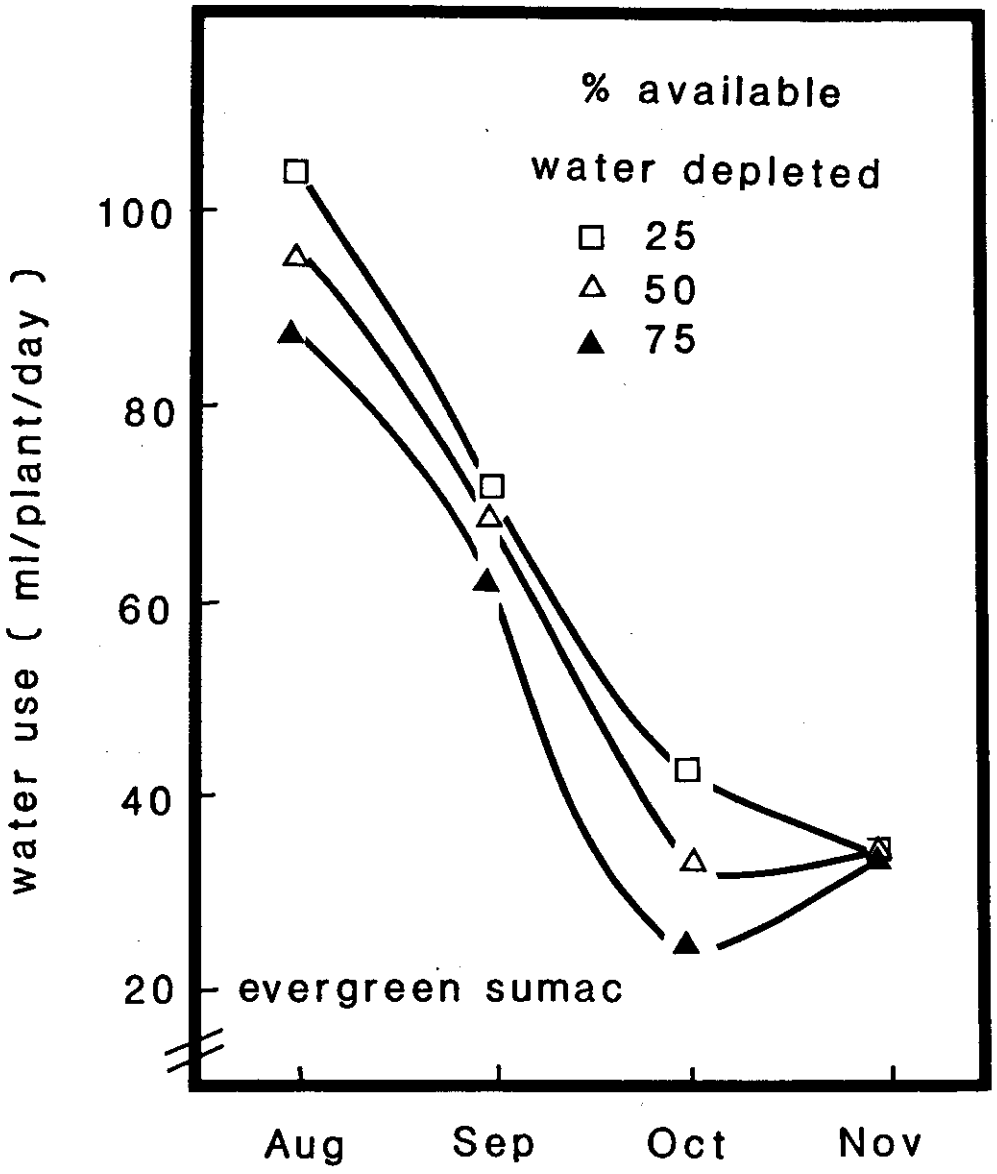

Fig. 16. Daily water use by evergreen sumac (Rhus virens) at 3 moisture levels during a 4 month period.

the crane scales used in the study was 0.1% of the load. This was about 0.15 cm of water. The water use values obtained from the daily weighings are given in Appendix Tables 5-9.

Soil Moisture Measurements

Soil moisture measurements that were made periodically indicated that soil moisture was being extracted from the lower soil depths (76 cm) by cenizo, St. Augustinegrass and buffalograss under dry treatment and from one lysimeter each of buffalograss and St. Augustinegrass under the wet treatment. These data are given in Appendix Table 10.

LITERATURE CITED

1. Anonymous, Water Use, Projected Water Requirements, and Related Data and Information for the Standard Metropolitan Statistical Areas in Texas. 1981. CP-141. Texas Department of Water Resources, P. O. Box 13087, Austin, TX. 78711.

2. Brown, K. W., C. J. Gerard, B. W. Hipp and J. T. Richie. 1974. A procedure for placing large undisturbed monoliths in lysimetrs. Soil Sci. Soc. Amer. Proc. 38:981-983.

3. Correll, D.S. and M. C. Johnston. 1970. Manual of the vascular plants of Texas. Texas Res. Foundation. Renner, TX.

4. Cotter, D. J. and D. B. Croft. 1974. Water application practices and landscape attributes associated with residential water consumption. Tech. Rpt. 049. New Mex. Water Resources Res. Inst., Las Cruces, NM.

5. Danielson, Robert E., Charles M. Feldhake, and William E. Hart. 1981. Urban Lawn Irrigation and Management practices for water saving with minimum effect on lawn quality. Colo. Water Resources Research Institute Completion Report 106. Colo. State Univ., Fort Collins, Colo.

6. Fairbourn, Merle L., W. D. Kemper and H. R. Gardner. 1970. Effects of row spacing on evapotranspiration and yields of corn in a semiarid environment. Agron. J. 62:795-797.

7. Gerard, C. J., B. W. Hipp and S. A. Reeves. 1977. Yields growth and management, requirements of selected crops as influenced by soil properties. Tex. Agric. Exp. Sta. B-1172.

8. Gerard, C. J. and B. W. Hipp. 1975. Irrigation and soils studies on sugarcane. Tex. Agric. Exp. Sta. Tech. Rep. No. 75-2. p.50.

9. Haney, Richard A. Jr. (Ed.) 1977. Water conservation for domestic users. Univ. of Arizona Water Resources Research Center and Office of Arid Lands Studies. Tucson, AZ.

10. Harrold, Lloyd L. 1958. Lysimeter checks on Empirical Evapotranspiration values. Ag. Eng. Feb. 94-97.

11. Harrold, L. L. and F. R. Dreibelbis. 1958. Evaluation of agricultural hydrology by monlith lysimeter. U.S. Dept. Agr. Tech. Bull. 1179. p. 166.

12. Houston, C. E. 1955. Consumptive use of water by alfalfa in western Nevada. Nev. Agr. Exp. Sta. Bul. 191.

13. Kneebone, William R. and Ian L. Pepper. 1982. Consumptive water use by sub-irrigated turfgrasses under desert conditions. Agron. J. 74:419-423.

14. Marsh, Albert W., Ralph A. Strohman, Stan Spaulding, Victor Younger and Victor Gibeault. Circa 1975. Detrmining the water requirements of various turfgrass species. Mimeographed Report. Univ. of Calif. Riverside.

15. Miller, Marvin N., Dan L. Gunter, Bryan E. Melton, Charles R. Johnson and James T. Midcap. 1980. Selecting economically optimal levels of fertilization and irrigation for container production of woody ornamentals. J. Amer. Soc. Hort. Sci. 105(5)766-768.

16. McGuinness, J. L., F. R. Dreibelbis and L. L. Harrold. 1961. Soil moisture measurements with the neutron method supplement weighing lysimeters. Soil Sci. Soc. Amer. Proc.: 339-342.

17. Reddy, M. Devender, I. Krishnamurthy, K. Anand Reddy and A. Venkatachari. 1980. Consumptive use and daily evapotranspiration of corn under different levels of nitrogen and moisture regimes. Plant and Soil 56:143-147.

18. Ritchie, J. T. and W. R. Jordan. 1972. Dryland evaporative flux in a subhumid climate: IV. Relation to plant water status. Agron. J. 64:173-176.

19. Robins, J. S. 1965. In C. A. Black (Ed). Methods of soil analysis. I. Am. Soc. Agron. No. 9. Madison, Wisc.

20. Tanner, C. B. 1967. In Hagen, Haise, Edminister (Ed). Irrigation of agricultural lands. Agronomy 11:534-574.

21. Teare, I. D., H. Schimmelpfennig and R. P. Waldren. 1973. Rainout shelter and drainage lysimeters to quantitatively measure drought stress. Agron. J. 65:544-547.

22. Tipton, J. L. and E. L. McWilliams. 1979. Ornamental potential of the Creosotebush (Larrea tridentata). In Proceedings of Int. Arid Lands Conf. on Plant Resources. Texas Tech. U. July 1979. pp. 699-711.

23. Tovey, Rhip, J. S. Spencer and Dean C. Muckel. 1969. Turfgrass evapotranspiration. Agron. J. 61:863-867.

24. van Bavel, C. H. M. 1961. Lysimetric measurements of evapotranspiration rates in the eastern United States. Soil Sci. Soc. Amer. Proc. 25:138-141.

Table A-1. Evaporation from a class A pan at Dallas, Tx, 1981.

Date (Period Ending)	Days/Period	cm Evaporation Per Day	cm Evaporation Per Period	Cumulative (cm)
9/10	7	0.66	4.62	4.62
9/17	7	0.58	4.06	8.68
9/24	7	0.72	5.04	13.72
10/01	7	0.79	5.53	19.25
10/21	20	0.33	6.60	25.85
10/29	8	0.37	2.96	28.81
11/06	8	0.26	2.08	30.89
11/12	6	0.20	1.20	32.09
11/20	8	0.36	2.88	34.97
11/28	8	0.41	3.28	38.25
12/04	6	0.43	2.56	40.82

Table A-2. Evaporation from a Class A pan at Dallas, TX 1982

Date	Days/ Period	cm Evaporation Per Day	cm Evaporation Per Period	Cumulative (cm)
06/04	31	0.74	22.94	22.94
06/11	7	0.95	6.65	29.59
06/24	13	1.10	14.30	43.89
07/09	15	1.02	15.30	59.19
07/14	5	0.96	4.80	63.99
07/19	5	1.08	5.40	69.39
07/21	2	1.02	2.04	71.43
07/28	7	0.83	5.81	77.24
08/04	7	0.76	5.32	82.56
08/09	5	1.03	5.15	87.71
08/12	3	0.69	2.07	89.78
08/19	7	1.09	7.63	97.41
08/27	8	1.08	8.64	106.05
09/03	7	1.08	7.56	113.61
09/10	7	0.91	6.37	119.98
09/17	7	0.80	5.60	125.58
09/24	7	0.81	5.67	131.25
10/01	7	0.78	5.46	136.71
10/13	12	0.64	7.68	144.39
10/15	2	0.45	0.90	145.29
11/01	17	0.46	7.82	153.11
11/09	8	0.42	3.36	156.47
11/16	7	0.37	2.59	159.06
11/22	6	0.22	1.32	160.38
11/29	7	0.29	2.03	162.41
12/06	7	0.20	1.40	163.81
12/15	9	0.20	1.80	165.61
12/21	6	0.32	1.92	167.53

Table A-3. Evaporation from a class A pan at Dallas, TX. 1983.

Date (Period Ending)	Days Period	cm Evaporation Per Day	cm Evaporation Per Period	Cumulative (cm)
01/11	21	0.24	5.04	5.04
02/3	23	0.24	5.52	10.56
03/14	39	0.37	14.43	24.99
03/29	15	0.45	6.75	31.74
04/11	13	0.57	7.41	39.15
04/18	7	0.81	5.67	44.82
04/25	7	0.53	3.71	48.53
05/9	14	0.80	11.20	59.73
05/16	7	0.42	2.94	62.67
05/26	10	0.75	7.50	70.17
06/3	8	0.68	5.44	75.61
06/9	6	0.85	5.10	80.71
06/16	7	0.93	6.51	87.22
06/23	7	0.99	6.93	94.15
06/30	7	0.87	6.09	100.24
07/7	7	0.96	6.72	106.96
07/15	8	0.87	6.96	113.92

Table A-4. Transpiration ranges for native landscape plants under uncontrolled conditions at Dallas, Tx in September 1982.

plant	Transpiration rate micrograms/cm2/sec
Chilopsis linearis (desert willow)	0.6-11.4
Arbutus xalapensis (madrone)	0.3- 4.4
Cotinus obovatus (smoke tree)	0.2- 5.7
Campsis radicans (trumpet creeper)	1.4-17.7
Tecoma stans 'angustata' (yellow bells)	1.2- 9.5

Table A-5. Daily water use (cm) by cenizo during August 1982 at Dallas, TX.

Date	Irrigated at 0.30 Bar at 30 cm		Irrigated at 0.40 Bar at 76 cm	
	Lys 4	Lys 12	Lys 3	Lys 8
08/10	0.12	0.19	0.48	1.08
08/11	0.23	0.23	0.88	1.31
08/12	0.19	0.32	0.44	0.94
08/13	0.37	0.94	1.10	1.50
08/14	0.30	0.55	1.04	1.72
08/15	0.37	0.42	1.08	1.61
08/16	0.07	0.37	0.99	1.33
08/17	0.20	0.33	0.77	1.14
08/18	0.21	0.23	0.41	0.96
08/19	0.14	0.39	1.04	1.50
08/20	0.30	1.04	1.33	1.70

Table A-6. Daily water use (cm) by boxwood during August 1982 at Dallas, TX.

Date	Irrigated at 0.30 Bar at 30 cm		Irrigated at 0.40 Bar at 76 cm	
	Lys 6	Lys 7	Lys 2	Lys 11
08/10	0.35	0.27	0.18	0.11
08/11	0.51	0.50	0.04	0.04
08/12	0.27	0.32	0.18	0.25
08/13	0.50	0.58	0.42	0.30
08/14	0.48	0.35	0.14	0.19
08/15	0.11	0.23	0.02	0.12
08/16	0.27	0.25	0.34	0.18
08/17	0.17	0.04	0.06	0.04
08/18	0.14	0.58	0.11	0.11
08/19	0.12	0.46	0.12	0.07
08/20	0.19	0.48	0.12	0.16

Table A-7. Daily water use (cm) by Texas barberry during August 1982 at Dallas, TX.

Date	Irrigated at 0.30 Bar at 30 cm		Irrigated at 0.40 Bar at 76 cm	
	Lys 1	Lys 10	Lys 5	Lys 9
08/10	0.19	0.18	0.12	0.42
08/11	0.16	0.07	0.07	0.37
08/12	0.28	0.16	0.05	0.12
08/13	0.87	0.23	0.34	0.57
08/14	0.53	0.32	0.23	0.18
08/15	0.25	0.11	0.27	0.23
08/16	0.37	0.18	0.07	0.74
08/17	0.20	0.25	0.08	0.38
08/18	0.14	0.50	0.14	0.32
08/19	0.27	0.28	0.11	0.62
08/20	0.30	0.34	0.16	0.39

Table A-8. Daily water use (cm) by buffalograss during August 1982 at Dallas, TX.

Date	Irrigated at 0.30 Bar at 30 cm		Irrigated at 0.40 Bar at 76 cm	
	Lys 15	Lys 18	Lys 14	Lys 19
08/10	0.21	0.46	0.39	0.46
08/11	0.48	0.51	0.35	0.39
08/12	0.19	0.18	0.18	0.16
08/13	0.71	0.80	1.04	0.62
08/14	0.81	0.65	0.71	0.60
08/15	0.80	0.85	0.73	0.60
08/16	0.64	0.41	0.46	0.50
08/17	0.47	0.34	0.47	0.31
08/18	0.35	0.44	0.34	0.37
08/19	0.34	0.51	0.42	0.42
08/20	0.73	0.71	0.62	0.69

Table A-9. Daily water use (cm) by St. Augustinegrass during August 1982 at Dallas, TX.

Date	Irrigated at 0.30 Bar at 30 cm	Irrigated at 0.40 Bar at 76 cm		
	Lys 20	Lys 13	Lys 16	Lys 17
08/10	0.27	0.41	0.51	0.04
08/11	0.44	0.41	0.46	0.46
08/12	0.16	0.09	0.05	0.27
08/13	0.73	0.71	0.83	0.71
08/14	0.76	0.83	0.69	0.76
08/15	0.71	0.65	0.53	0.60
08/16	0.39	0.50	0.71	0.67
08/17	0.48	0.47	0.47	0.48
08/18	0.50	0.39	0.42	0.42
08/19	0.48	0.34	0.37	0.41
08/20	0.67	0.69	0.62	0.80

Table A-10. Soil moisture content in Lysimeters on various dates during 1982. (Volumetric %)

lysimeter	depth (cm)	5/25	8/2	8/12	8/19	8/30	9/8	10/4	
1	20	42.5	36.1	23.2	25.3	21.0	29.8	29.2	
Barberry - wet	40	42.5	40.1	41.3	40.2	40.7	40.3	39.9	
	76	43.3	41.3	41.8	41.1	41.4	41.4	41.4	
		5/25	7/19	9/14					
2	20	42.5	31.0	17.2					
Boxwood - dry	40	42.5	38.0	35.9					
	76	43.3	41.5	40.4					
		5/25	7/19	7/27	8/2	8/14	8/17	8/23	
3	20	42.5	31.8	33.9	35.4	20.2	25.2	17.8	
Cenizo - dry	40	42.5	32.2	33.1	34.9	33.8	34.2	32.8	
	76	43.3	41.4	40.3	41.2	39.1	39.6	36.9	
		8/27	9/7	9/13	9/16	9/27	9/30	10/15	10/19
3 (Cont'd)	20	24.5	20.1	23.6	27.7	22.3	26.8	25.4	27.7
	40	33.6	32.8	33.9	34.6	34.3	35.0	34.9	35.1
	76	37.9	37.0	39.0	40.2	38.8	41.0	39.3	41.4
		5/25	7/19	8/20	9/3	9/16	10/5		
4	20	42.5	40.5	21.0	27.4	27.7	22.9		
Cenizo - wet	40	42.5	43.0	40.4	40.6	34.6	40.6		
	76	43.3	41.8	39.9	40.5	40.2	41.6		
		5/25	7/19	9/14					
5	20	42.5	36.5	20.0					
Barberry - dry	40	42.5	41.8	40.0					
	76	43.3	43.0	41.0					
		5/25	7/19	8/9	8/24	9/7	9/17		
6	20	42.5	41.0	39.0	27.1	28.6	30.0		
boxwood - wet	40	42.5	42.8	43.2	42.6	42.8	42.0		
	76	43.3	44.0	43.5	43.9	42.9	43.3		
		5/25	7/19	7/30	8/9	8/17	8/23		
7	20	42.5	38.0	37.4	39.7	18.6	27.6		
boxwood - wet	40	42.5	42.9	42.7	42.2	37.8	42.6		
	76	43.3	43.0	42.1	42.3	37.9	42.1		

lysimeter	depth (cm)							
		8/27	9/8	9/15	10/4	10/6		
7 (Cont'd)		34.8	31.6	31.7	30.7	34.5		
		42.5	41.7	42.4	43.2	42.1		
		42.2	41.9	42.4	42.3	42.4		
		5/25	7/27	8/2	8/5	8/6	8/11	8/13
8	20	42.5	29.4	35.1	33.4	37.4	39.7	22.7
Cenizo - dry	40	42.5	33.1	37.3	35.4	36.3	37.9	33.3
	76	43.3	33.6	36.6	34.8	35.5	35.9	35.5
		8/17	8/27	8/31	9/3	9/7	9/8	
8 (Cont'd)		18.6	25.5	32.9	16.8	15.3	19.0	
		37.8	36.0	36.1	36.6	36.3	37.5	
		37.9	36.3	36.7	36.9	36.3	36.6	
		9/13	9/24	9/30	10/15	10/25		
8 (Cont'd)		15.6	18.7	18.9	19.6	21.9		
		36.2	38.0	37.6	37.8	38.4		
		35.9	37.6	37.9	37.7	38.1		
		5/25	7/19	8/15	8/17	8/27	9/8	9/15
9	20	42.5	41.0	35.2	22.9	30.0	36.0	36.4
Barberry - dry	40	42.5	42.5	42.9	42.9	42.9	42.4	43.0
	76	43.3	42.8	42.9	42.6	43.5	43.4	43.0
		5/25	7/19	8/16	9/10			
10	20	42.5	42.0	28.0	30.9			
Barberry - wet	40	42.5	43.5	42.6	42.7			
	76	43.3	41.5	40.8	42.0			
		5/25	9/14					
11	20	42.5	14.8					
Boxwood - dry	40	42.5	40.4					
	76	43.3	41.7					
		5/25	7/19	8/10	8/18	8/24		
12	20	42.5	35.8	33.6	22.6	29.1		
Cenizo - wet	40	42.5	40.7	42.9	42.3	41.7		
	76	43.3	43.8	43.7	43.7	43.7		

lysimeter	depth (cm)							
		8/30	9/7	9/13	9/24	9/30	10/6	10/7
(12 Cont'd)		25.3	29.0	30.0	31.5	31.6	31.0	37.5
		41.2	39.8	40.4	41.4	41.1	40.3	42.6
		43.7	42.9	42.7	43.2	42.5	42.7	43.8
		5/25	7/27	8/13	8/26	9/10	10/5	
13	20	42.5	35.2	30.1	32.1	32.0	33.0	
St. Augustine - dry	40	42.5	36.5	35.9	36.3	36.6	37.5	
	76	43.3	40.3	37.5	38.4	38.8	38.8	
		5/25	8/12	9/1	10/6			
14	20	42.5	29.1	31.4	33.3			
Buffalo - dry	40	42.5	33.0	33.9	34.5			
	76	43.3	34.9	35.0	35.1			
		5/25	7/30	8/10	8/17	8/24		
15	20	42.5	37.8	42.6	28.9	33.2		
Buffalo - wet	40	42.5	40.6	42.1	40.9	40.6		
	76	43.3	42.1	44.0	41.7	41.8		
		9/1	9/9	9/10	10/4			
15 (Cont'd)		34.2	33.9	38.6	35.3			
		41.3	41.6	42.2	41.4			
		41.8	42.4	44.5	41.8			
		5/25	7/19	8/2	8/15	8/27	9/13	
16	20	42.5	35.2	36.8	28.4	22.9	29.2	
St. Augustine - dry	40	42.5	34.7	35.5	35.2	34.9	35.4	
	76	43.3	37.6	37.3	37.5	37.5	36.7	
		5/25	7/19	8/9	8/24	9/7	10/1	
17	20	42.5	33.7	34.6	25.9	26.4	27.1	
St. Augustine - dry	40	42.5	36.6	35.4	37.2	37.4	37.3	
	76	43.3	36.9	32.9	36.9	37.5	38.1	
		5/25	7/19	7/27	8/6	8/16	8/24	
18	20	42.5	34.3	37.4	37.0	31.6	32.4	
Buffalo - wet	40	42.5	34.7	38.1	37.9	37.9	38.0	
	76	43.3	33.9	36.3	36.5	36.6	37.2	
		9/3	9/13	9/14	10/7			
18 (Cont'd)		31.6	31.8	37.3	32.6			
		37.7	37.9	38.7	37.9			
		36.1	36.7	37.5	37.4			

lysimeter	depth (cm)	5/25	7/19	7/27	8/5	8/18	9/4			
19	20	42.5	36.9							
Buffalo - dry	40	42.5	34.6							
	76	43.3	37.2							
		5/25	7/19	7/27	8/5	8/16	8/27	9/3	9/7	10/4
20	20	42.5	34.9	36.0	36.8	31.9	28.3	32.4	33.3	34.3
St. Augustine - wet	40	42.5	36.2	37.3	38.2	38.3	39.5	38.7	39.3	38.8
	76	43.3	36.8	38.5	38.6	39.0	39.5	38.7	39.0	39.1

Fig. 3. Placing a lysimeter inside the metal liner.

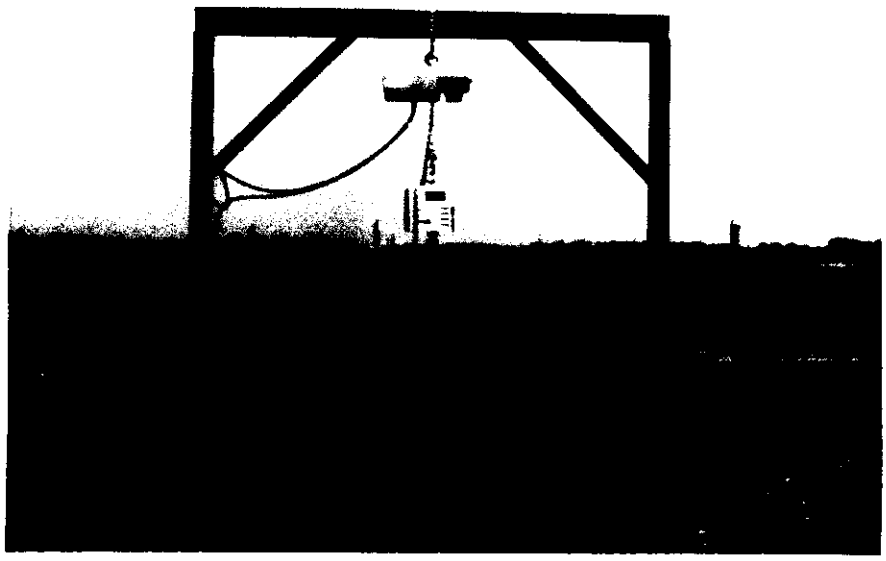

Fig. 4. Tower, weighing and lifting mechanism, and tracks used in weighing the lysimeters.

Fig. 1. Soil was shaved away from the cutting edge and frame in preparation for pushing the lysimeter into the soil to obtain an undisturbed soil core.

Fig. 2. Placement of the porous ceramic suction cups and tubing in the bottom of lysimeters.