Protocol for Water Needs of Shrubs during Establishment

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INTRODUCTION

Water is a vital part of every aspect of human life, preserving and managing it has become a challenge for every industry, including the landscape industry. It is not clear how much water shrubs need to be established in a landscape, or how long it takes for them to become established. It is thought that it takes about 4 to 6 months to establish a 3-gallon shrub with modest irrigation management, but this is just an estimate and many factors play a role in how much water is required for establishment. Thus, the objective of this project is to determine how much irrigation is needed to establish and maintain shrubs installed in Florida landscapes.

PROGRESS

This project, which has been operating for 9 months, seeks to determine the impact on the irrigation needs of newly planted shrubs. Furthermore, the project seeks to correlate location in Florida and irrigation frequency with evapotranspiration to develop models for calculating water budgets for shrub establishment. For the fulfillment of these questions, the following working objectives, as well as those included in Progress Report #1, have been met:

A. Phase one, part 1

Objectives 1 thru 5 have been completed.

Objective six in progress. Cooperating nurseries have been identified through the Tampa Bay Wholesale Growers and the Florida Nursery, Growers and Landscape Association. These nurseries donate the plant material and deliver to Apopka, the central location, for pickup by individuals from each site. Temporary holding areas have been established at each site.

Objective eight in progress. In September 2004, installation of shrubs in test plots began at Balm, Citra, and Fort Lauderdale. Three species of shrubs, *Viburnum odoratissimum* (Viburnum), *Ilex cornuta* 'Burfordii Nana' (Burford Holly), and *Pittosporum tobira*, 'Variegata' (Pittosporum) were planted from #3 containers at Balm and Citra. Because of poor performance at the Fort Lauderdale site, Pittosporums and Burford hollies were replaced by *Murraya paniculata* 'Lakeview' (Orange jasmine) and *Psychotria nervosa* (Wild coffee).

Each species of shrub was irrigated at one of the following irrigation frequencies: Irrigation 1 (every 2 days), Irrigation 2 (every 4 days), Irrigation 3 (every 7 days), and Irrigation 4 (the mix treatment, a combination of frequencies starting everyday for the first 2 weeks after planting, every 2 days for the next two weeks, every 4 days for the following four weeks, then every 7 days until established). Each treatment was replicated six times. A total of 72 plants were planted at each site. Each plant received 3 liters of water per irrigation event. Planted rows were mulched with pine bark mulch to a thickness of 3 inches and 6' x 138' strips.

Best management fertilizer practices were followed for optimal maintenance of plants. Lesco Southern Ornamental Landscape Fertilizer (12-2-14) was applied at a rate of 1 lb. N /1000 sq. ft. Plots were treated with Roundup Pro® to control weeds between rows.

Objective nine in progress.

Water stress measurements - Predawn, mid-day, and dusk water potentials were recorded at 28-day intervals to study the effect of irrigation frequencies. Three random samples (plants) per treatment per species were selected to record water potential data. The sampling dates correspond with maximum and minimum water stress levels for each treatment. Water potentials were taken the day prior to irrigation (maximum stress day) and the day of irrigation (minimum stress) (Appendix 1 readings done in November, two months after planting).

Comparisons of water potentials between stressed and unstressed plants and differences between dawn and dusk water potentials on the day of irrigation were examined to determine species ability to recover from water stress and trends toward establishment in the landscape (Figs. 7 through 24). Water potential measurements must be within 1 bar to be considered established. This is an indication that the plants have developed a sufficient root system to utilize irrigation water provided after a period of stress.

In Balm, predawn and dusk water potential measurements indicate that all species exhibit recovery from water stress dependent on treatment. Burford hollies, Pittosporum, and Viburnum were unable to recover in response to the 2-day irrigation, 7 day irrigation, and 7-day and mix treatments, respectively. (Figs. 8, 10 and 12). Burford hollies watered every 7 days exhibited the greatest stress (Figs. 7 and 8). Similar results were found for Viburnum (Figs. 11 and 12). No clear trends could be identified among Pittosporum (Figs. 9 and 10).

In Citra, the recovery of the Pittosporums was not as prominent (Fig. 16). Both Burford hollies and Viburnums recovered well from the water stress with the exception of the 7-day treatment (Figs. 13, 17, and 18). Among Burford hollies, the most stressed plants were those watered every 7 days (Figs. 13 and 14).

In Fort Lauderdale, the readings for the Wild coffee watered every 2 and 4 days could not be taken due to plants killed or damaged by hurricane Frances and Jeanne (Figs. 19 and 20). Differences in predawn and dusk water potentials on the day of irrigation indicate that Orange jasmine and Wild coffee are becoming established (Figs 19-22). Orange jasmine had the lowest water potentials in response to the 4-day treatment. Wild coffee exhibited the greatest stress with the mix treatment.

Measurements of Viburnum suggest plants are becoming established with the exception of the 2-day treatment (Figs. 23 and 24).

Plant growth - Effect of irrigation treatments on plant growth was tracked by measuring average canopy height, widest canopy width (width 1), and the width perpendicular to the widest width (width 2). The measurements were taken every 28 days and growth indices were then calculated using the formula Growth Index = height x width 1 x width 2 (Appendix 2).

In Balm, there was an overall increase in growth for all treatment and species combinations (Tables 4, 5 and 6). In Burford hollies the growth was similar for all four treatments with and average increase of 31% of the starting growth index at the end of the third month of readings (Table 4). In Pittosporums, the greatest growth was for plants that got watered every 2 days (125% increase) and the least for plants watered every 7 days (76% increase), while plants that were irrigated every 4 days or under the Mix treatment behaved similarly, with an increase of 106% and 103%, respectively (Table 5). In Viburnums, the greatest increase was observed for plants watered every 2 days (75%), followed by those under the Mix treatment (57%), those watered ever 4 days (38%), and those watered every 7 days (35%) (Table 6).

In Citra, growth over time increased for all species in response to all treatments (Tables 7, 8, and 9). However, no clear trends relative to the effect of different treatments on growth could be identified. Similar results were found in Fort Lauderdale (Tables 10, 11, and 12), with the exception of Wild coffee under the Mix treatment, which does not appear to be growing well (Table 10).

Root excavations – To measure root spread, root excavation will be performed at 12, 20, and 28 weeks after planting (WAP).

B. Phase one, part 2.

Objectives 1 through 4 have been completed.

Objective five in progress. A contractor, Jeff Warren Construction, 6441 Plymouth Sorrento Rd. Apopka, FL 32712, has been secured and construction of the drainage lysimeters begun in mid-November. Due to the cement shortage, the cost is $12,000 over that budgeted.

C. Additional two studies.

Study One in Apopka - On 11 Aug 2004, three species, *Viburnum odoratissimum, Ilex cornuta* 'Burfordii Nana', and *Pittosporum tobira* 'Variegata' were transplanted from #3 containers into an open-sided rain-out shelter in Apopka. Each treatment was managed with Best Management Practices with the exception of irrigation regime. Each species was irrigated at one of the following frequencies: every 2 days, every 4 days or every 7 days. Each plant received 9 liters per irrigation event. Treatments were replicated 4 times in a randomized complete block design.

Predawn, mid-day, and dusk water potentials were taken at 28-day intervals beginning at days 55 and 56 after transplanting (Appendix 1). All shrubs or replicates in each treatment were sampled the day prior to irrigation and the day of irrigation.

Sampling dates were chosen to correspond with maximum and minimum water stress levels. Water potential readings were not taken at days 27 and 28 following planting due to the effects of Hurricanes Charley, Frances, and Jeanne. Stomatal conductance measurements were taken at approximately 3-hour intervals between dawn and dusk on the sampling dates.

On the day of maximum stress, the 7-day treatment resulted in more negative water potentials for Burford holly and Pittosporum (Fig 1 and 3). Viburnum receiving irrigation every 4 days exhibited the greatest negative water potential on the day prior to irrigation (Fig. 2). On irrigation day, water potentials decreased dramatically relative to the previous day with minimal differences in water potential among treatments (Figs 1 through 6). Water potential measurements between stressed and unstressed plants indicate that all species regardless of treatment recovered from water stress following irrigation. The data suggest that all species are becoming established after two months.

Growth indices were recorded immediately after planting and at 28-day intervals as previously described. Burford hollies (Table 1) and Viburnum (Table 3) had larger plant canopies when receiving irrigation every 2 days. Similar trends were not observed between Pittosporum, with growth indices greatest for the 7-day treatment (Table 2).

Study two in Citra- A second plot was planted on November 2004 to replicate the planting in May 2004 (details on the first progress report). This will provide us with a comparison of irrigation volume and frequency effects in spring vs. fall planting.

Irrigation for shrubs installed in May was discontinued 11 WAP (11 Aug). Despite no irrigation, no differences in plant size or quality were found among shrubs receiving 3, 6, or 9 liter per irrigation event. Midday water potentials were taken starting in October (1 Oct through 22 Nov) during which time there was stretch of 33 days with no rain (Appendix 3). Data indicate that plants were more stressed than the established indicator plants but can withstand an extended dry period 4 months after planting (Tables 13, 14, and 15). As of mid December 2004, the plants had not been watered for the last eight weeks and displayed no visual signs of stress.

APPENDIX 1. Water Potential

APOPKA

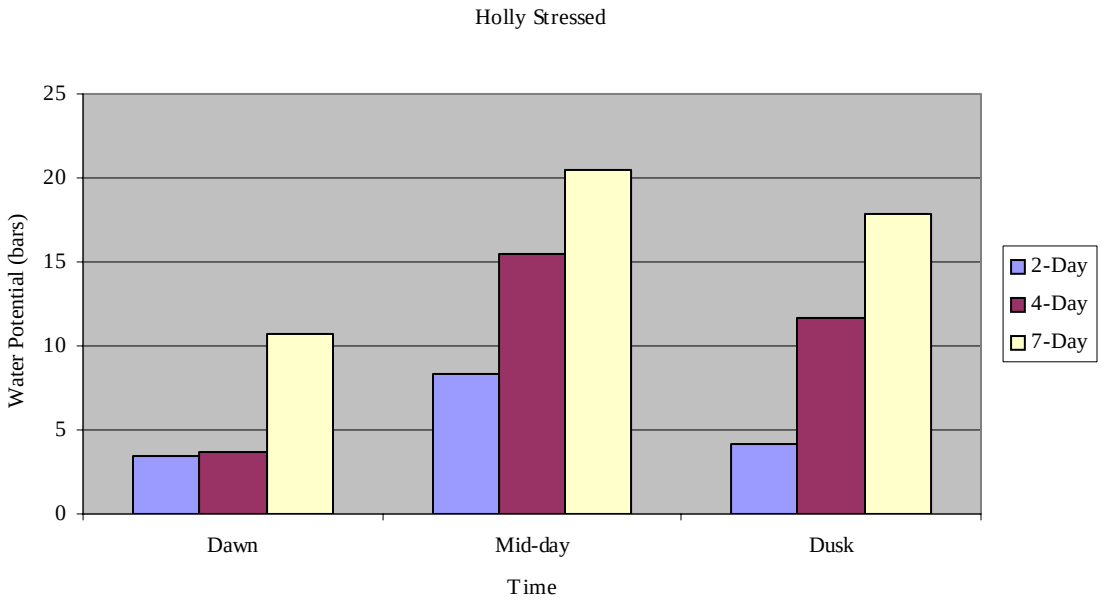

Figure 1. Effect of the time of the day on water potential in *Ilex cornuta* 'Burfordii Nana' under stressed conditions two months after planting, Apopka, Florida.

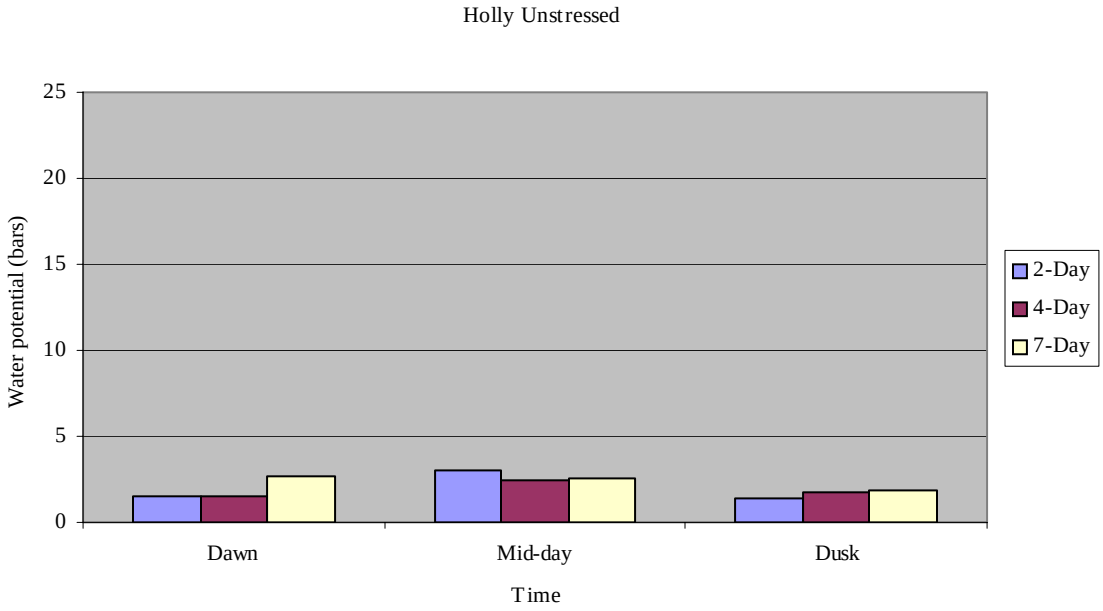

Figure 2. Effect of the time of the day on water potential in *Ilex cornuta* 'Burfordii Nana' under unstressed conditions two months after planting, Apopka, Florida.

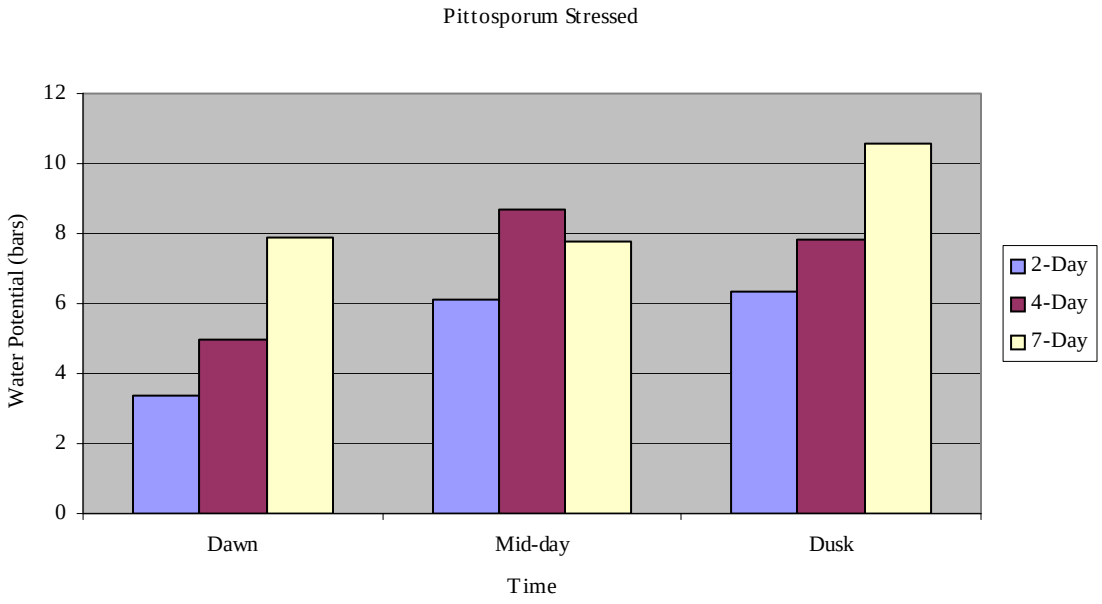

Figure 3. Effect of the time of the day on water potential in *Pittosporum tobira* 'Variegata' under stressed conditions two months after planting, Apopka, Florida.

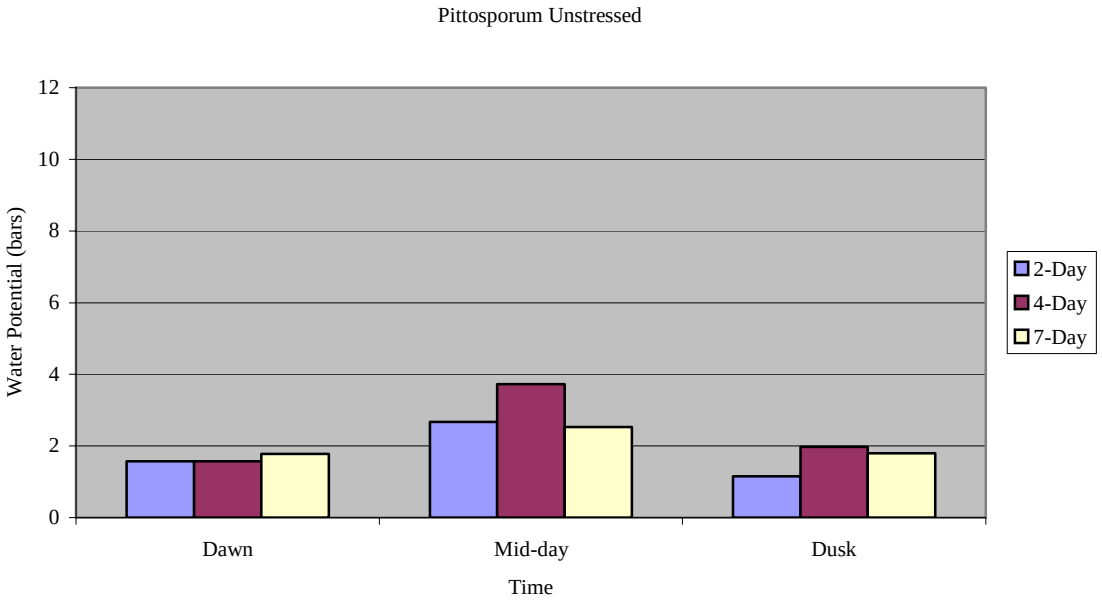

Figure 4. Effect of the time of the day on water potential in *Pittosporum tobira* 'Variegata' under unstressed conditions two months after planting, Apopka, Florida.

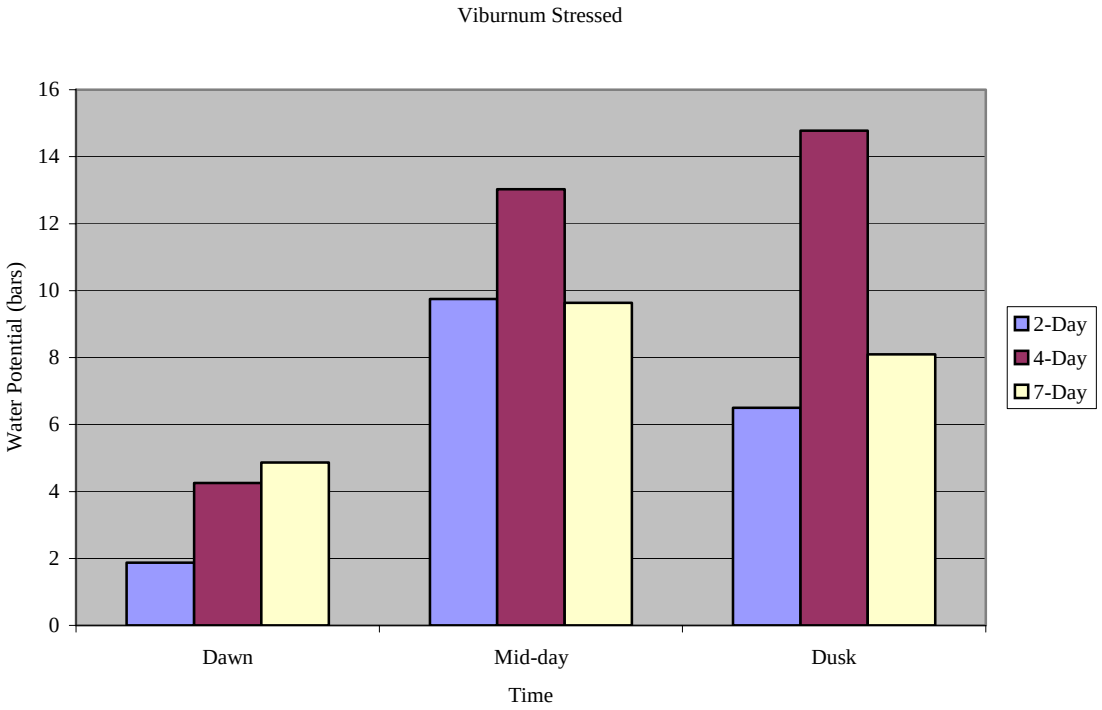

Figure 5. Effect of the time of the day on water potential in *Viburnum odoratissimum* under stressed conditions two months after planting, Apopka, Florida.

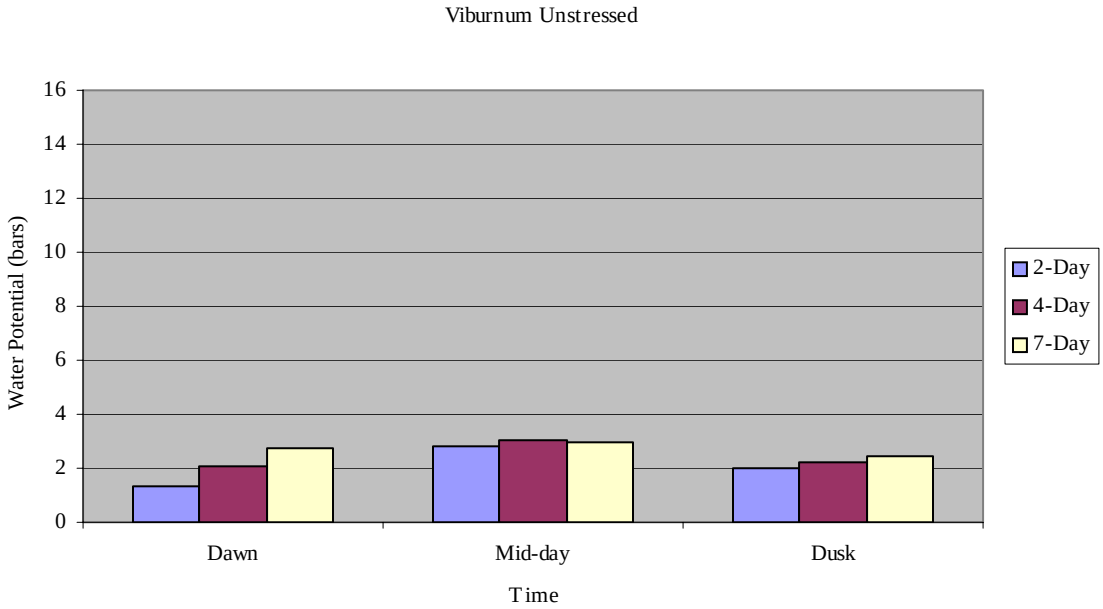

Figure 6. Effect of the time of the day on water potential in *Viburnum odoratissimum* under unstressed conditions two months after planting, Apopka, Florida.

BALM

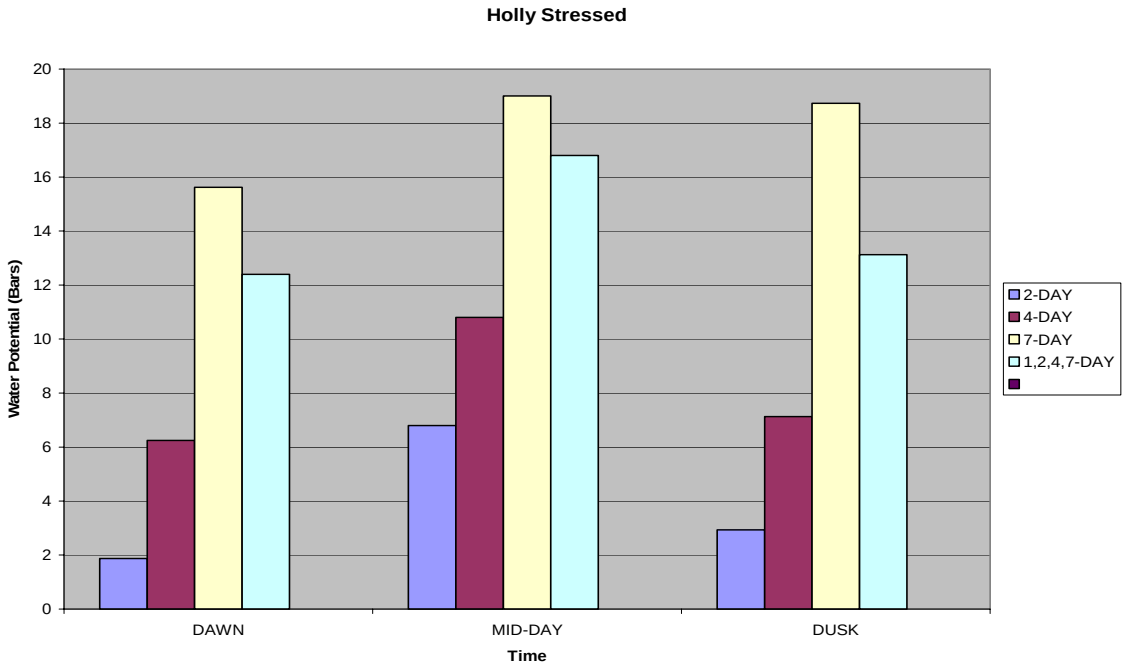

Figure 7. Effect of the time of the day on water potential in *Ilex cornuta* 'Burfordii Nana' planted in September under stressed conditions two months after planting, Balm, Florida.

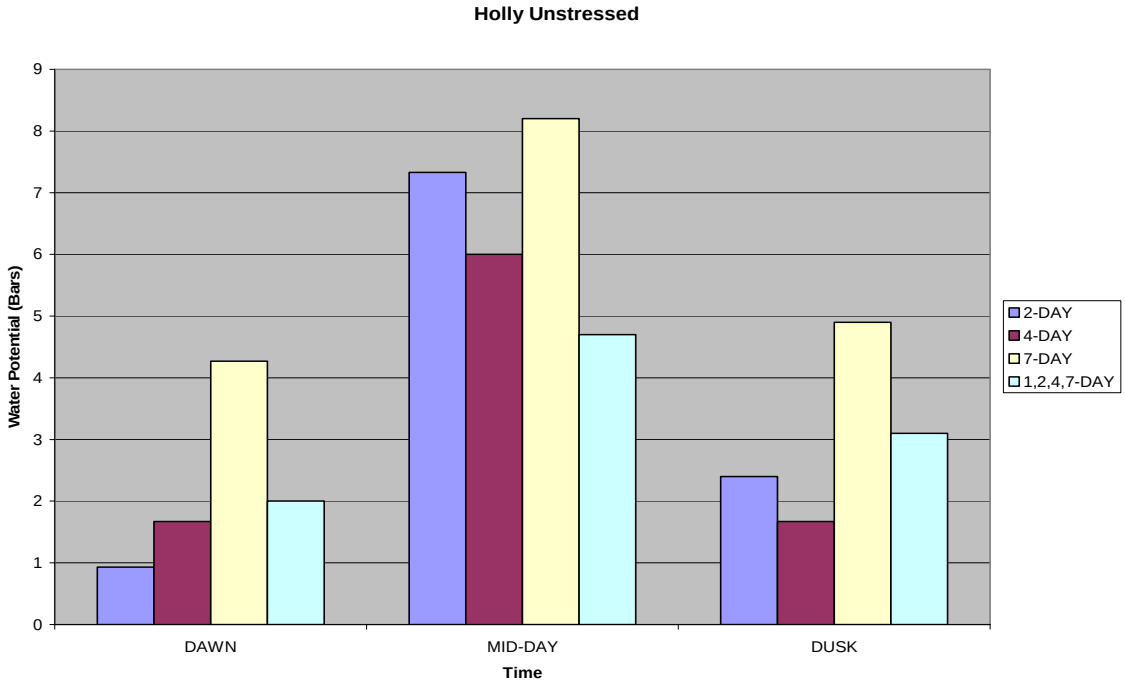

Figure 8. Effect of the time of the day on water potential in *Ilex cornuta* 'Burfordii Nana' planted in September under unstressed conditions two months after planting, Balm, Florida.

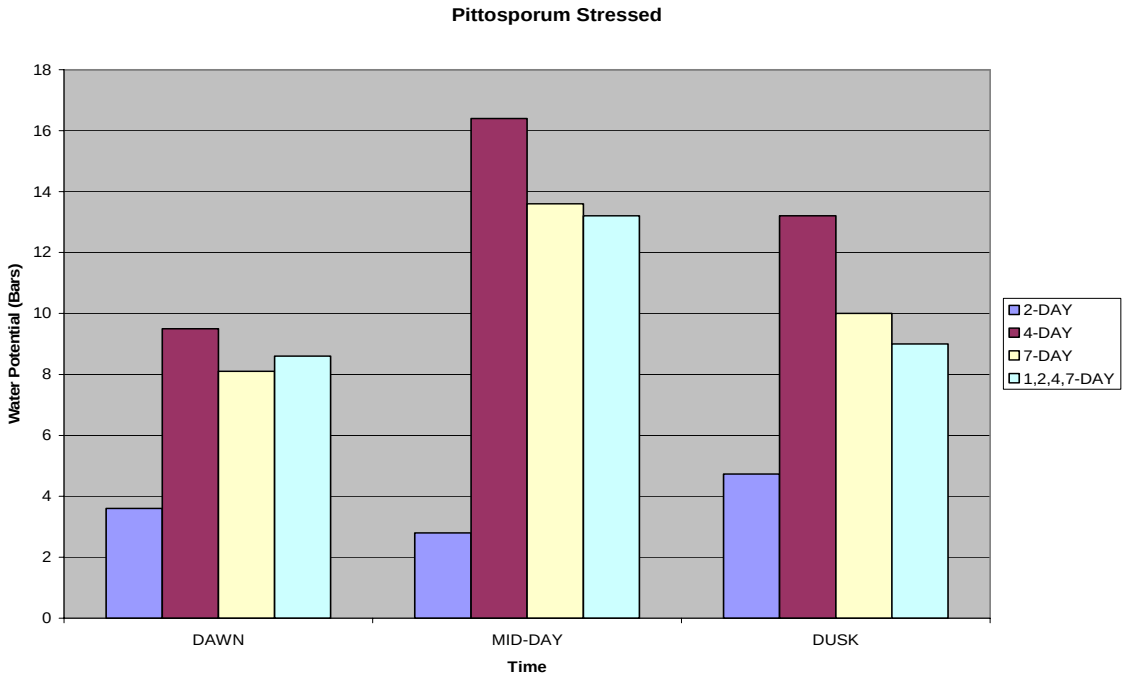

Figure 9. Effect of the time of the day on water potential in *Pittosporum tobira* 'Variegata' planted in September under stressed conditions two months after planting, Balm, Florida.

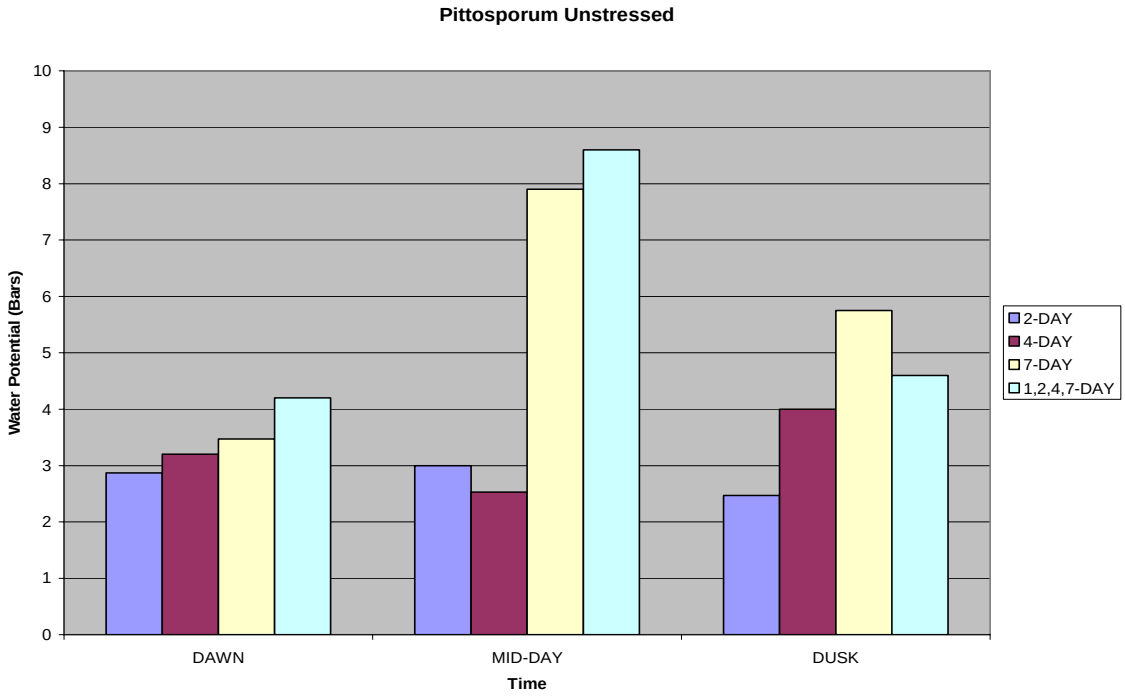

Figure 10. Effect of the time of the day on water potential in *Pittosporum tobira* 'Variegata' planted in September under unstressed conditions two months after planting, Balm, Florida.

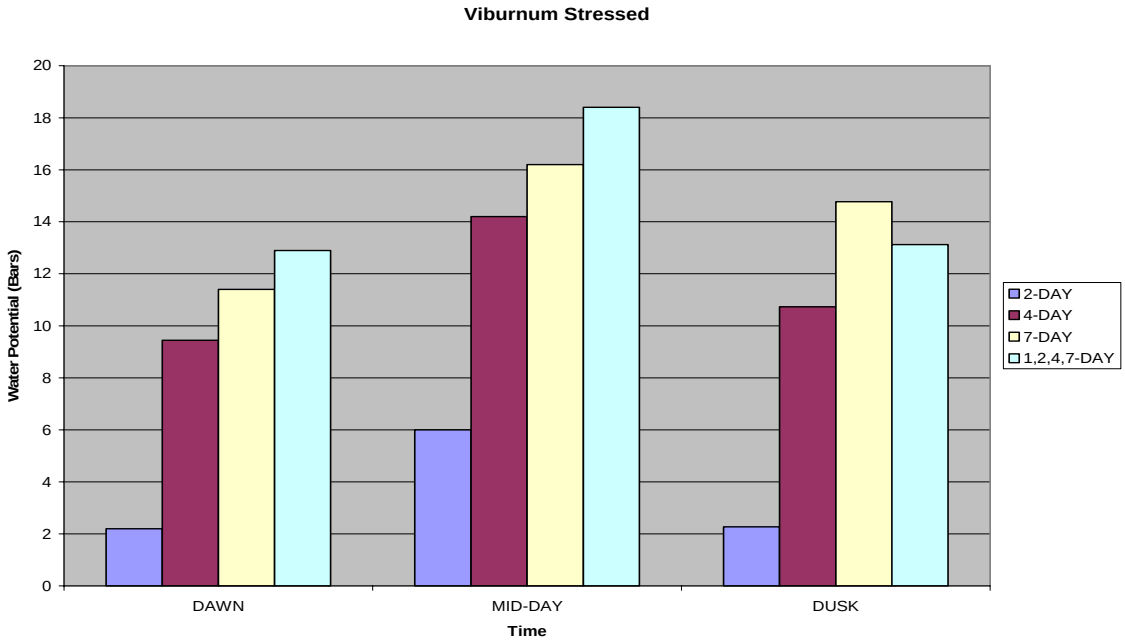

Figure 11. Effect of the time of the day on water potential in *Viburnum odoratissimum* planted in September under stressed conditions two months after planting, Balm, Florida.

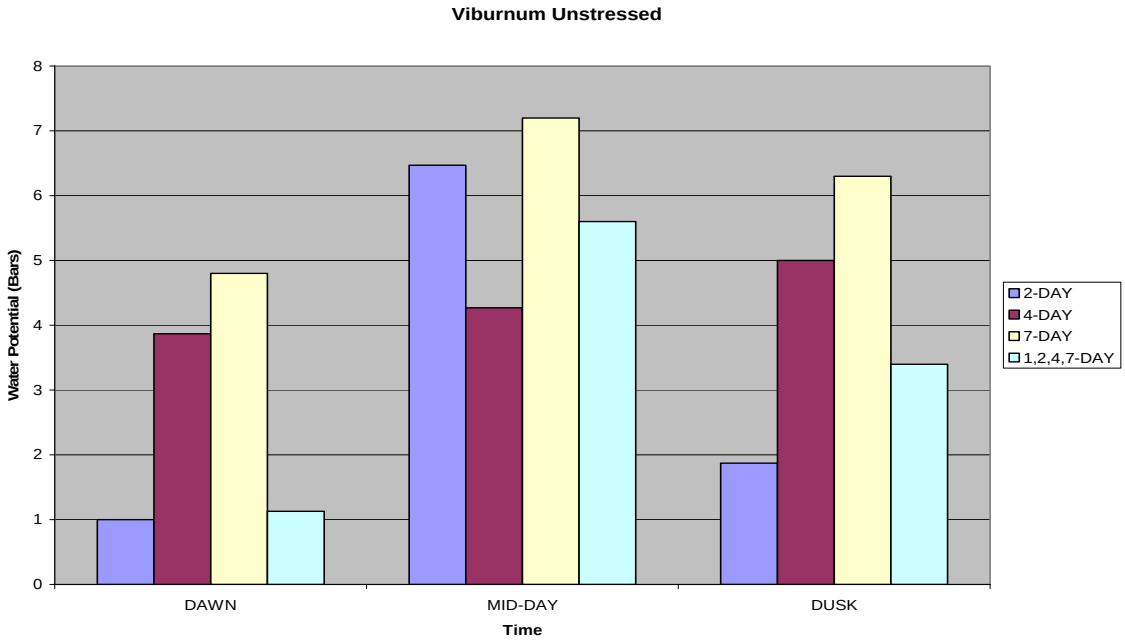

Figure 12. Effect of the time of the day on water potential in *Viburnum odoratissimum* planted in September under unstressed conditions two months after planting, Balm, Florida.

CITRA

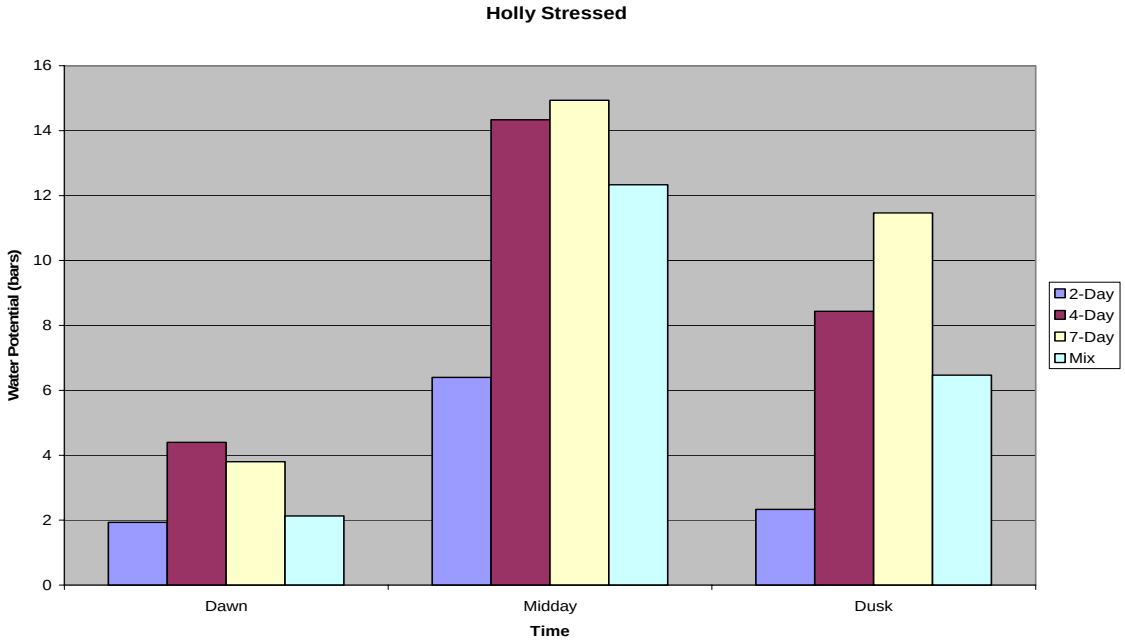

Figure 13. Effect of the time of the day on water potential in *Ilex cornuta* 'Burfordii Nana' planted in September under stressed conditions two months after planting, Citra, Florida.

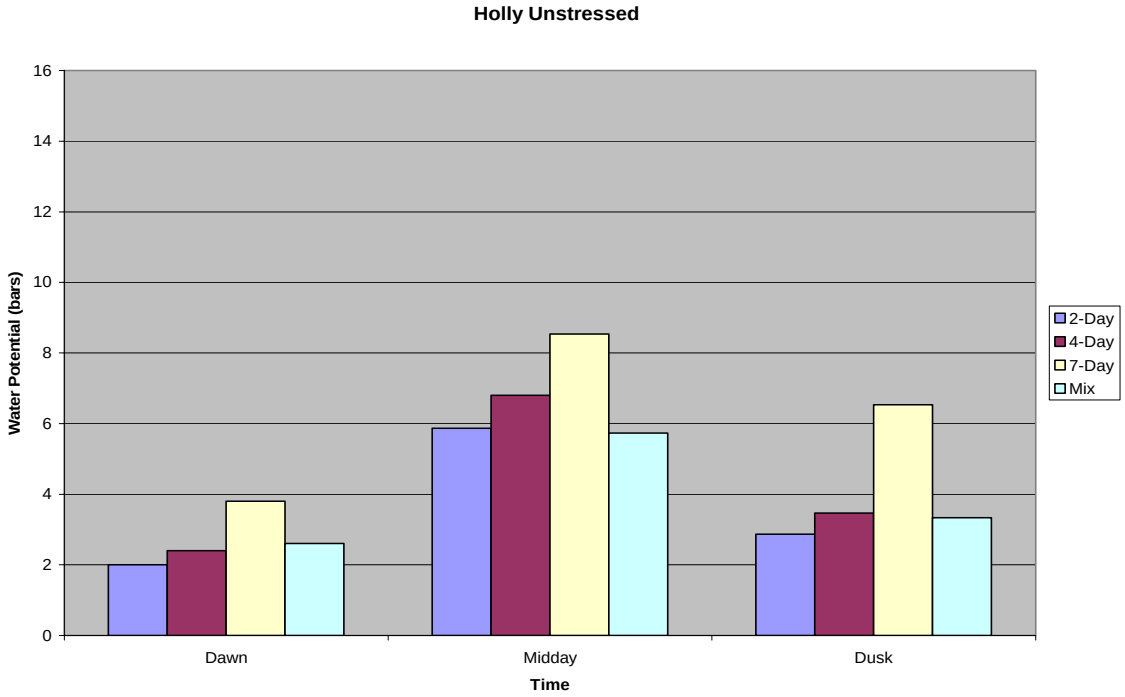

Figure 14. Effect of the time of the day on water potential in *Ilex cornuta* 'Burfordii Nana' planted in September under unstressed conditions two months after planting, Citra, Florida.

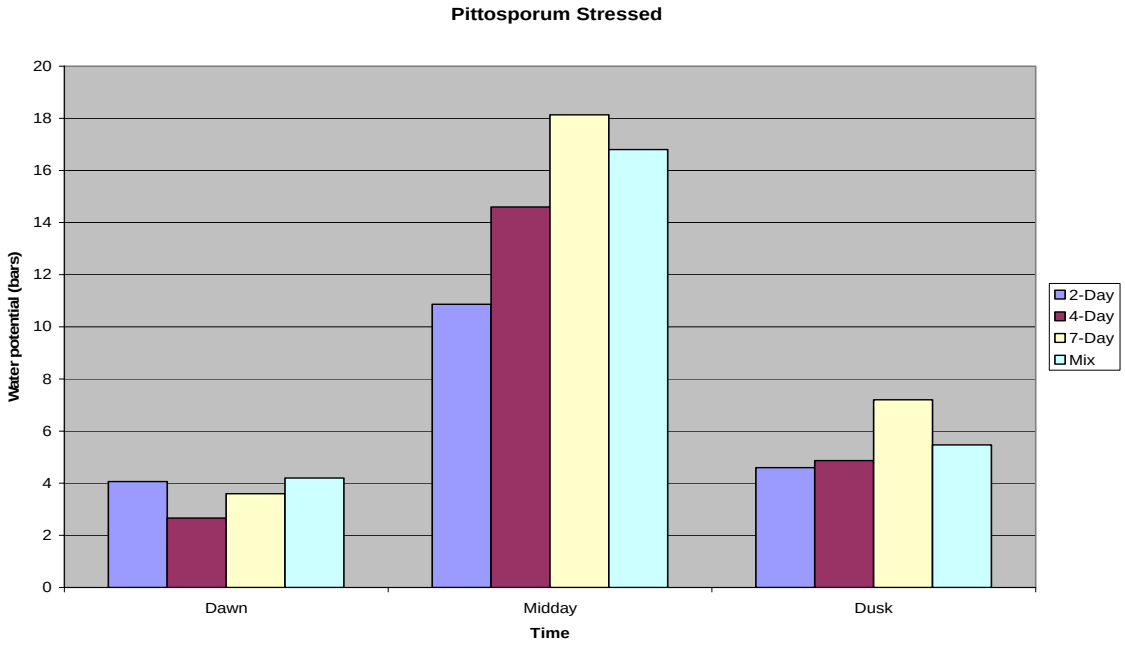

Figure 15. Effect of the time of the day on water potential in *Pittosporum tobira* 'Variegata' planted in September under stressed conditions two months after planting, Citra, Florida.

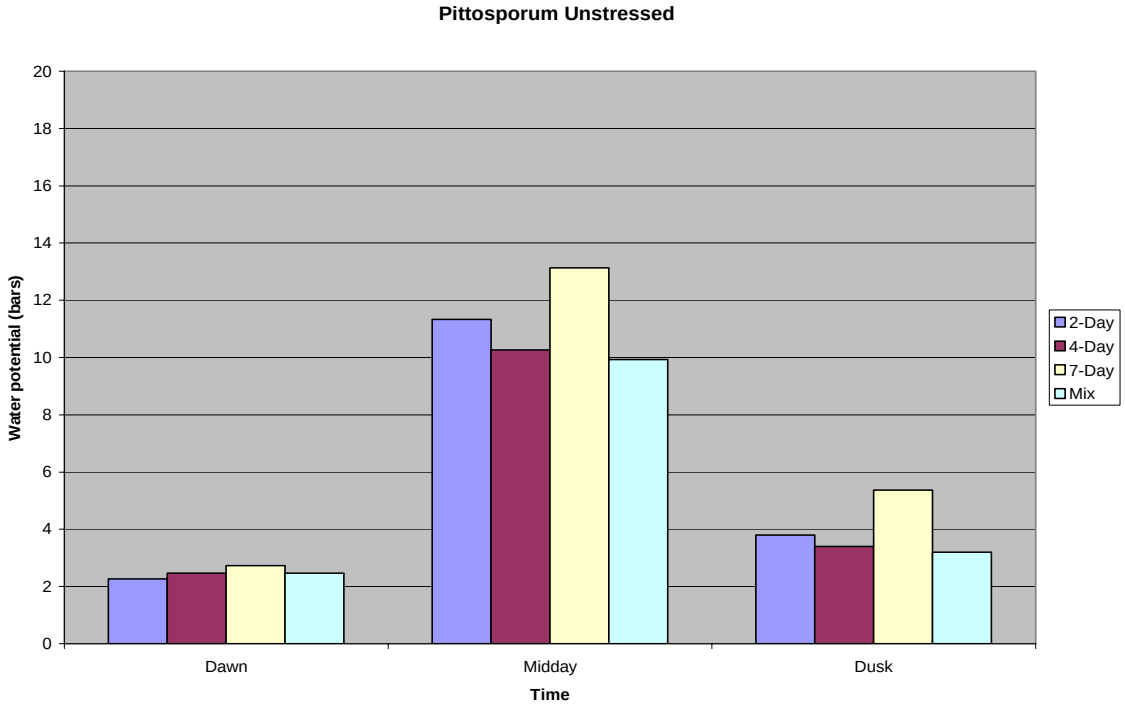

Figure 16. Effect of the time of the day on water potential in *Pittosporum tobira* 'Variegata' planted in September under unstressed conditions two months after planting, Citra, Florida.

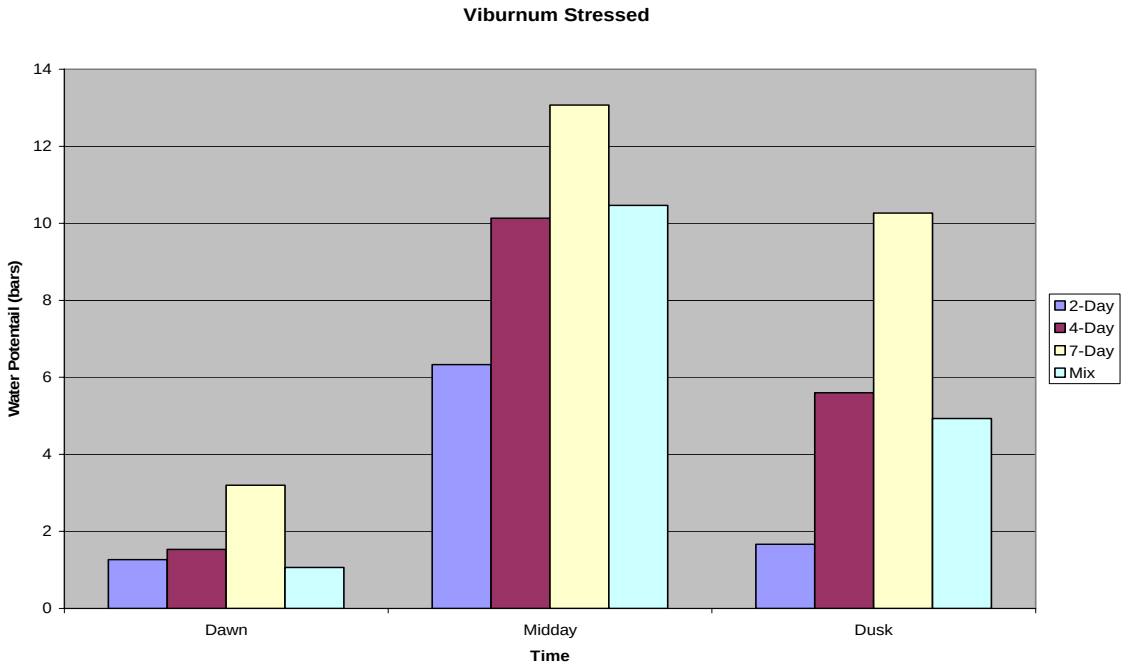

Figure 17. Effect of the time of the day on water potential in *Viburnum odoratissimum* planted in September under stressed conditions two months after planting, Citra, Florida.

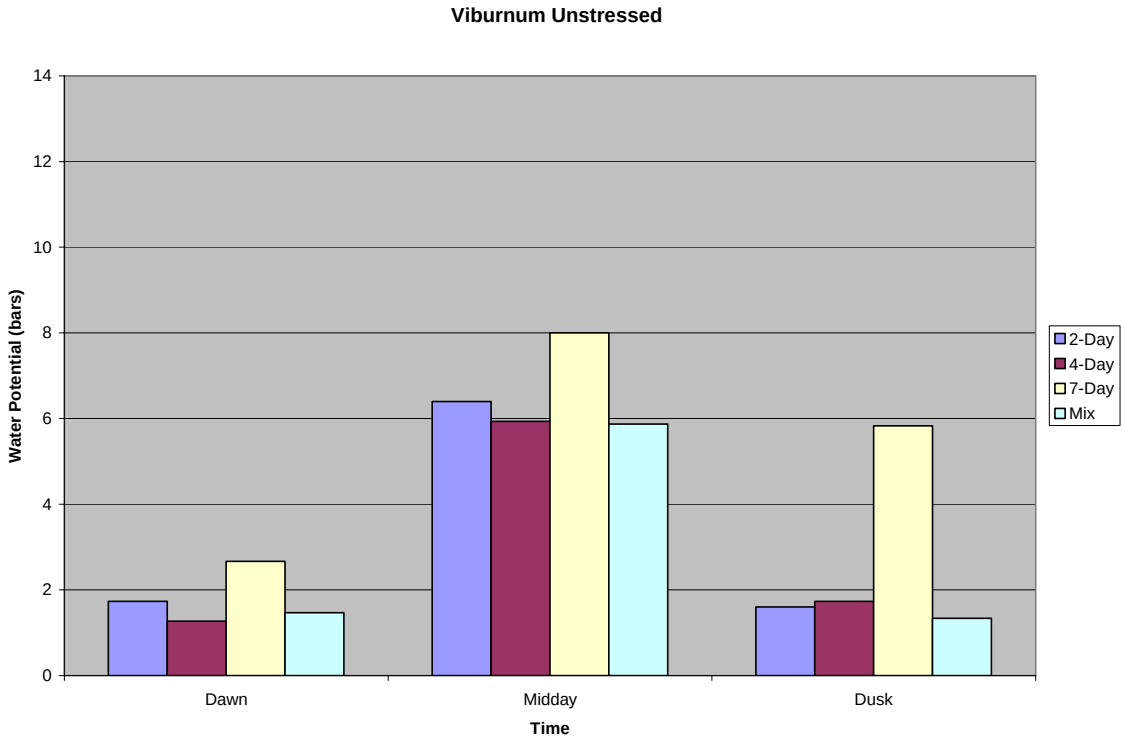

Figure 18. Effect of the time of the day on water potential in *Viburnum odoratissimum* planted in September under unstressed conditions two months after planting, Citra, Florida.

FORT LAUDERDALE

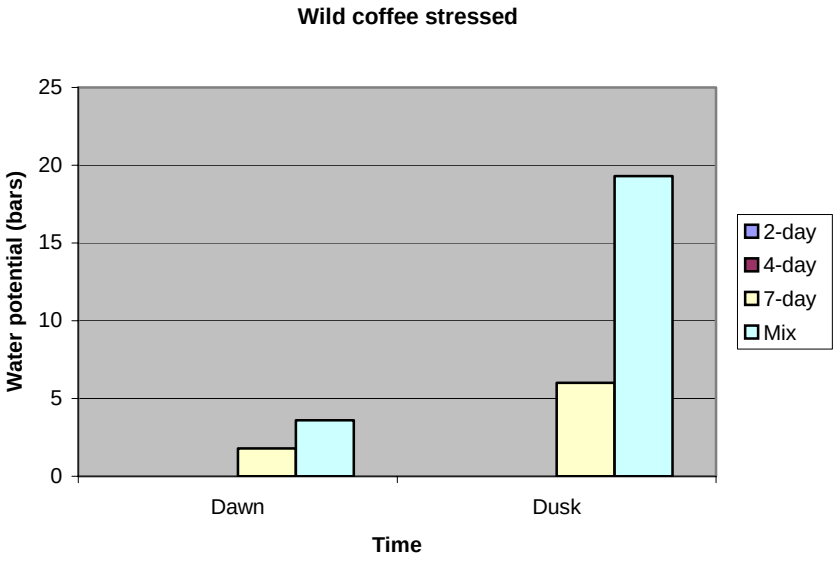

Figure 19. Effect of the time of the day on water potential in *Psychotria nervosa* planted in September under stressed conditions two months after planting, Fort Lauderdale, Florida. (4-Day treatment could not be measured.)

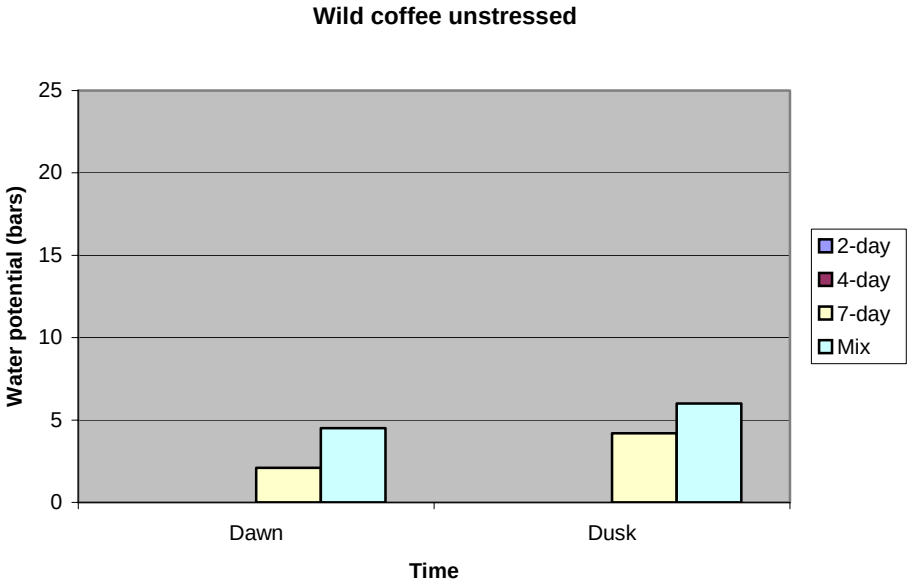

Figure 20. Effect of the time of the day on water potential in *Psychotria nervosa* planted in September under unstressed conditions two months after planting, Fort Lauderdale, Florida (4-Day treatment could not be measured).

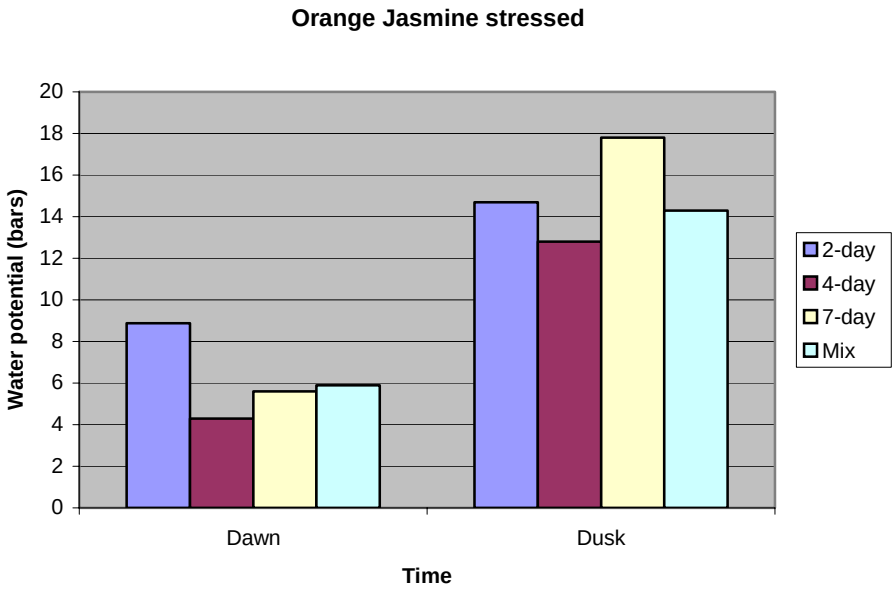

Figure 21. Effect of the time of the day on water potential in *Murraya paniculata* planted in September under stressed conditions two months after planting, Fort Lauderdale, Florida.

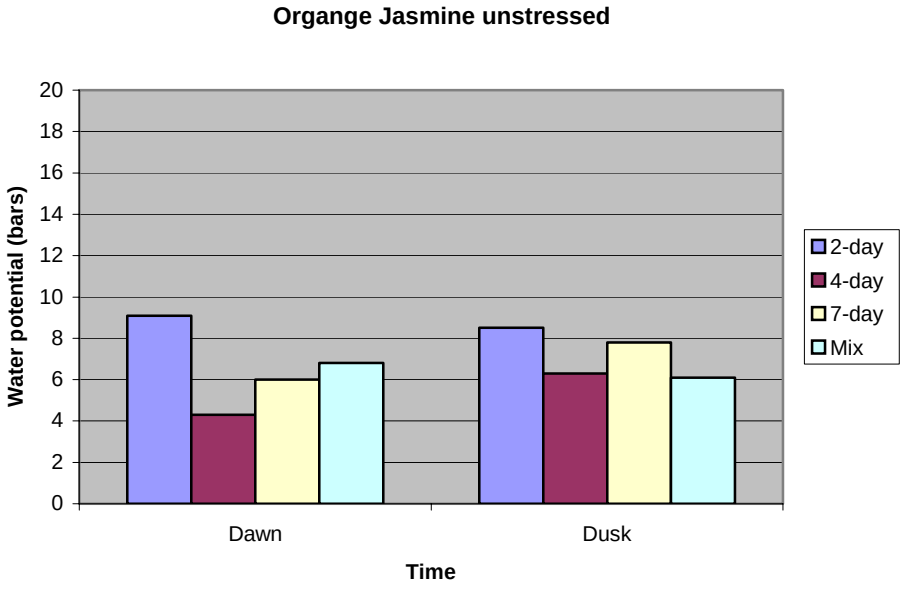

Figure 22. Effect of the time of the day on water potential in *Murraya paniculata* planted in September under unstressed conditions two months after planting, Fort Lauderdale, Florida.

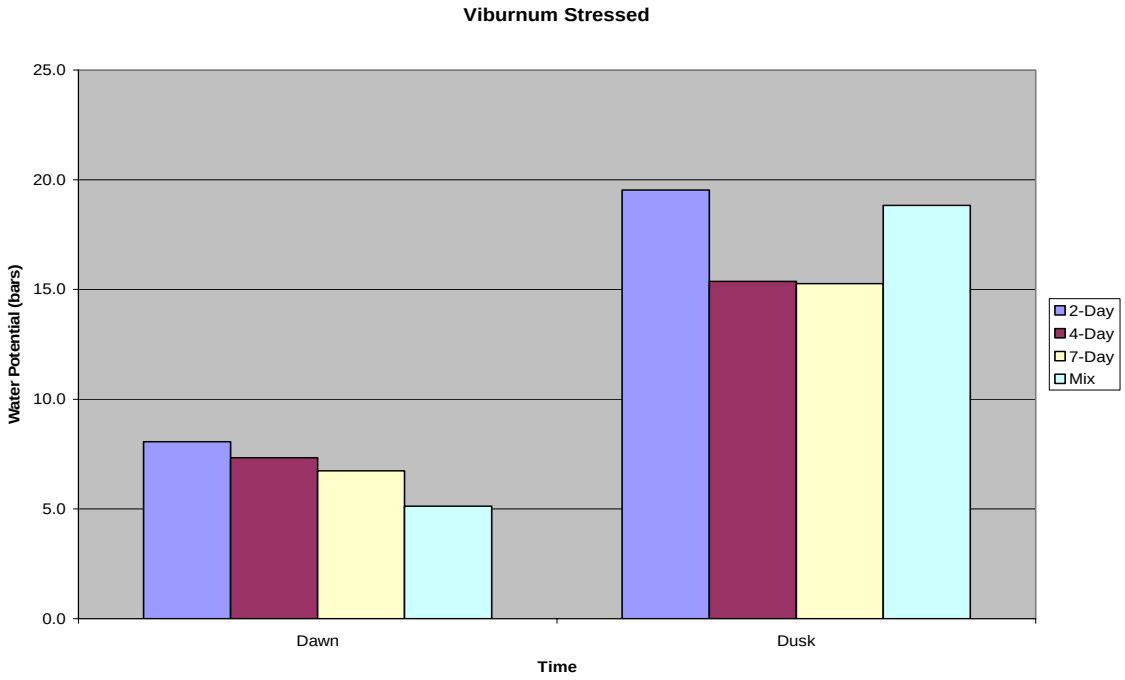

Figure 23. Effect of the time of the day on water potential in *Viburnum odoratissimum* planted in September under stressed conditions two months after planting, Fort Lauderdale, Florida.

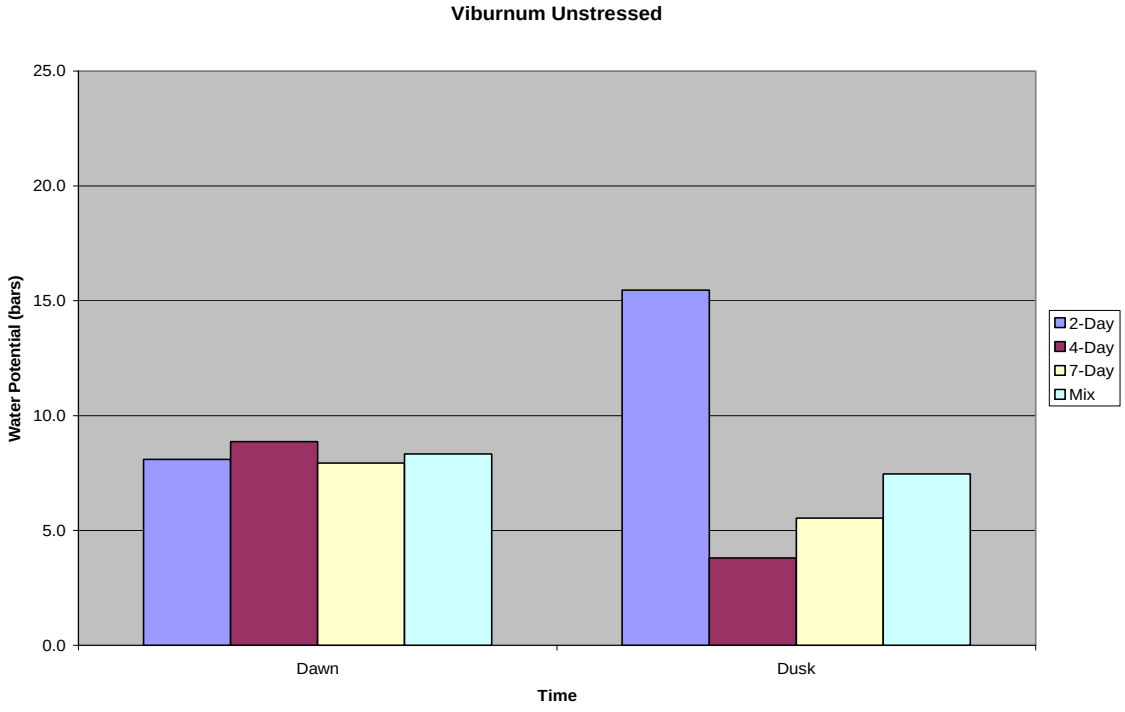

Figure 24. Effect of the time of the day on water potential in *Viburnum odoratissimum* planted in September under unstressed conditions two months after planting, Fort Lauderdale, Florida.

APPENDIX 2. Growth Indices.

APOPKA

Tables 1. Growth index (m^3) of *Ilex cornuta* 'Bufordii Nana' taken every 28 days starting at planting.

	Date		
Treatment	Aug.	Sept.	Oct.
2-day	0.1466*	0.1367	0.1325
4-day	0.1276	0.1349	0.1174
7-day	0.1110	0.1203	0.1067

*Growth Index= height x width 1 x width 2 (m^3).

Tables 2. Growth index (m^3) of *Pittosporum tobira* 'Variegata' taken every 28 days starting at planting.

	Date		
Treatment	Aug.	Sept.	Oct.
2-day	0.1046*	0.1055	0.0898
4-day	0.0931	0.1018	0.0955
7-day	0.1190	0.1168	0.1088

*Growth Index= height x width 1 x width 2 (m^3).

Tables 3. Growth index (m^3) of *Viburnum odoratissimum* taken every 28 days starting at planting.

	Date		
Treatment	Aug.	Sept.	Oct.
2-day	0.2547*	0.2449	0.2661
4-day	0.3461	0.2958	0.2191
7-day	0.2791	0.1488	0.0726

*Growth Index= height x width 1 x width 2 (m^3).

BALM

Tables 4. Growth index (m^3) of *Ilex cornuta* 'Bufordii Nana' taken every 28 days starting at planting.

	Date		
Treatment	Sept.	Oct.	Nov.
2-day	0.0912*	0.0988	0.1185
4-day	0.0885	0.0960	0.1185
7-day	0.0991	0.1117	0.1227
Mix	0.0875	0.1072	0.1193

*Growth Index= height x width 1 x width 2 (m^3).

Tables 5. Growth index (m^3) of *Pittosporum tobira* 'Variegata' taken every 28 days starting at planting.

	Date		
Treatment	Sept.	Oct.	Nov.
2-day	0.0373*	0.0378	0.0838
4-day	0.0298	0.0340	0.0613
7-day	0.0404	0.0487	0.0713
Mix	0.0369	0.0419	0.0749

*Growth Index= height x width 1 x width 2 (m^3).

Tables 6. Growth index (m^3) of *Viburnum odoratissimum* taken every 28 days starting at planting.

	Date		
Treatment	Sept.	Oct.	Nov.
2-day	0.1083*	0.1421	0.1900
4-day	0.1168	0.1320	0.1611
7-day	0.1125	0.1355	0.1520
Mix	0.1139	0.1610	0.1785

*Growth Index= height x width 1 x width 2 (m^3).

CITRA

Tables 7. Growth index (m^3) of *Ilex cornuta* 'Bufordii Nana' taken every 28 days starting at planting.

	Date		
Treatment	Sept.	Oct.	Nov.
2-day	0.1483*	0.1424	0.1695
4-day	0.1735	0.1796	0.1876
7-day	0.1489	0.1490	0.1704
Mix	0.1503	0.1506	0.1566

*Growth Index= height x width 1 x width 2 (m^3).

Tables 8. Growth index (m^3) of *Pittosporum tobira* 'Variegata' taken every 28 days starting at planting.

	Date		
Treatment	Sept.	Oct.	Nov.
2-day	0.0835*	0.0832	0.1214
4-day	0.0831	0.0845	0.1088
7-day	0.0770	0.0779	0.0848
Mix	0.0842	0.0860	0.1191

*Growth Index= height x width 1 x width 2 (m^3).

Tables 9. Growth index (m^3) of *Viburnum odoratissimum* taken every 28 days starting at planting.

	Date		
Treatment	Sept.	Oct.	Nov.
2-day	0.2541*	0.2871	0.2525
4-day	0.2908	0.2785	0.2915
7-day	0.3071	.03031	0.3088
Mix	0.3190	0.3085	0.3309

*Growth Index= height x width 1 x width 2 (m^3).

FORT LAUDERDALE

Tables 10. Growth index (m^3) of *Psychotria nervosa* taken every 28 days starting at planting.

	Date		
Treatment	Sept.	Oct.	Nov.
2-day	0.1994*	0.2134	0.2146
4-day	0.2605	0.2975	0.3118
7-day	0.1702	0.1903	0.1880
Mix	0.2694	0.2490	0.2681

*Growth Index= height x width 1 x width 2 (m^3).

Tables 11. Growth index (m^3) of *Murraya paniculata* 'Lakeview' taken every 28 days starting at planting.

	Date		
Treatment	Sept.	Oct.	Nov.
2-day	0.4771*	0.4906	0.5125
4-day	0.4793	0.5023	0.5327
7-day	0.4611	0.4441	0.4858
Mix	0.3284	0.4271	0.4312

*Growth Index= height x width 1 x width 2 (m^3).

Tables 12. Growth index (m^3) of *Viburnum odoratissimum* taken every 28 days starting at planting.

	Date		
Treatment	Sept.	Oct.	Nov.
2-day	0.2106*	0.2117	0.2272
4-day	0.2356	0.2249	0.2570
7-day	0.2336	0.2456	0.2701
Mix	0.2383	0.2436	0.3000

*Growth Index= height x width 1 x width 2 (m^3).

APPENDIX 3. Irrigation volume water potential.

Table 13. Midday water potential for *Ilex cornuta* 'Burfordii Nana' 20 weeks after planting at different stages of water stress under no irrigation, Citra, FL (October, 2004).

		Water potential (bars)						
Treatment	**Irrigation Volume (L)**	**2 days no rain**	**4 days no rain**	**7 days no rain**	**13 days no rain**	**16 days no rain**	**21 days no rain**	**33 days no rain**
2-Day	3	7.8	13	15.2	14	14.9	16.6	22.2
2-Day	6	8.6	13.2	16.1	16.3	19.2	20.2	24.2
2-Day	9	6.6	13.25	15.8	13.7	16.8	17.1	19.7
4-Day	3	10.9	9.9	16.6	18.5	21.3	21.8	24.6
4-Day	6	11.9	14.4	15.3	18.4	23.3	22.8	25
4-Day	9	8.7	14.3	14.7	15.1	18.3	21.8	26
Indicators		5.3	5	9.7	11.6	8.9	12.1	13.9

Table 14. Midday water potential for *Pittosporum tobira* 'Variegata' 20 weeks after planting at different stages of water stress under no irrigation, Citra, FL (October, 2004).

		Water potential (bars)						
Treatment	**Irrigation Volume (L)**	**2 days no rain**	**4 days no rain**	**7 days no rain**	**13 days no rain**	**16 days no rain**	**21 days no rain**	**33 days no rain**
2-Day	3	12.1	16.2	17.5	17.6	16.1	22	23.2
2-Day	6	15.2	14.5	21.2	19.9	17.3	23.6	21.3
2-Day	9	14.1	17.5	16.7	18.4	15.2	18.9	22.4
4-Day	3	16.4	17.3	18.6	20.5	19.2	23.4	24.2
4-Day	6	15.9	18.8	17.1	18.5	16.7	22	21.2
4-Day	9	16.3	12.3	16.9	17.5	15.6	21.6	23.6
Indicators		8.6	5.7	17	17.1	14.4	19.6	18.2

Table 15. Midday water potential for *Viburnum odoratissimum* 20 weeks after planting at different stages of water stress under no irrigation, Citra, FL (October, 2004).

		Water potential (bars)						
Treatment	**Irrigation Volume (L)**	**2 days no rain**	**4 days no rain**	**7 days no rain**	**13 days no rain**	**16 days no rain**	**21 days no rain**	**33 days no rain**
2-Day	3	10.9	12.6	10.4	12.7	14	16.2	20.5
2-Day	6	9.2	11.4	11.3	11.3	12.4	14.9	18.5
2-Day	9	10.7	11.8	10.8	12.4	14.4	15.1	20.8
4-Day	3	9.5	10.6	9.8	11.4	11.4	13.7	16.5
4-Day	6	9.8	11.5	10.2	11.8	10.9	14.2	16.1
4-Day	9	12	10.9	10.8	13.3	14	15.4	19.3
Indicators		6.2	9.3	12.6	13.3	14.5	16.4	20.2