days 17 and 18). Therefore, tensiometers are also useful outside the wetted area. With tensiometers inside and outside the wetted area it becomes a management decision whether low tensiometer readings outside the wetted area will delay irrigation. During the dry period of this study, after the 6 inch tensiometers inside the wetted area exceeded 15 centibars, the 6 inch tensiometers inside the wetted area were used for scheduling. These tensiometers responded to the replacement of water by the irrigation system (Fig. 4). The 6 inch tensiometers outside the wetted area continued to dry and were not affected by irrigation.

Once the decision was made to irrigate, the grower irrigated for ten hours. After ten hours of irrigation, the thirty-six inch tensiometers inside the wetted area responded showing that some irrigation water had reached this depth (Fig. 3). Since the root depth was approximately 30 inches, the duration of operation needed to be decreased until water no longer moved below the root zone. Five hour irrigation durations were tried from day 20 of the spring observation time. In practice, the tensiometers could be used to determine the length of time to operate the system. However, careful observations over a number of irrigations would be needed. Our present study ended before the five hour operating time could be verified for this irrigation system.

In this study, tensiometers were consistent from site to site. The only exception was that over extended periods of no rainfall, 6 inch tensiometer readings outside the wetted area diverged (Figs. 2 and 4). This site was specifically chosen for uniform soil, tree size and irrigation. Other sites, where those characteristics vary, may have a greater variation in soil moisture and therefore tensiometer station locations will have to be selected based on additional criteria. In groves with more than one soil type or soil moisture condition the tensiometer locations may be determined by which area of the grove has the greatest economic return. This may or may not be the section with the largest field area.

Summary

1. Tensiometers always responded to changes in soil moisture regardless of whether water was added by irrigation or rainfall or whether water was removed by the crop.

2. The shallow tensiometers reflected a more rapid moisture extraction, particularly outside the wetted area where prolonged moisture depletion occurred.

3. At this site, 6 inch tensiometers were the best indicators of available moisture in the root zone and therefore could be used for scheduling on sites similar to the study site.

4. Tensiometers are useful both inside and outside the wetted area where the irrigation system applies water to a small portion of the field area.

5. Tensiometers below the root zone can indicate when excess water has been applied. Also, if the tensiometers below the root zone start drying a larger irrigation or shorter duration is needed.

6. Tensiometer stations can be placed so as to represent the irrigation needs of the grove, however, many site specific factors influence the number of tensiometer stations needed. Knowledge of the grove and the irrigation system are needed along with a well thought out irrigation water management strategy in order to adequately irrigate the crop while getting the best use from the irrigation water.

7. Tensiometers may not be the appropriate tool for all soil types, however, our experience indicates they deserve wider use in the Florida citrus industry particularly on sandy textured soils.

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Proc. Fla. State Hort. Soc. 102:72-75. 1989.

THE TEXAS CITRUS INDUSTRY—1989

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Abstract. **The Texas citrus industry presently stands at 34,400 acres, which is almost half that which existed prior to the Christmas freeze of 1983. Recovery of lost acreage has been slower than anticipated, partly because of the removal of an additional 8,700 acres of trees that were initially undergoing freeze rehabilitation. Approximately 36% (12,300 acres) of present acreage has been planted since the freeze, leaving about 22,100 acres that survived the freeze.**

Overall tree density has increased to about 129 trees per acre, primarily because orchards established since the freeze are being planted at about 151 trees per acre. Grapefruit production in the 1988-89 season reached 46% of pre-freeze levels, but orange production was only 33% of previous levels. However, higher prices have resulted in a total industry value of $85.7 million, which is comparable to previous values of the Texas crop.

Approximately 4,000 acres of 'Rio Red' grapefruit have been planted, representing nearly 60% of all new grapefruit plantings and 20% of total grapefruit acreage. Approximately 60% of new orange orchards are 'Marrs' and other early varieties; 28% are navels and 12% are 'Valencia'. The ratio of acreage of grapefruit to oranges has steadily declined from 65:35 pre-freeze to 59:41 presently.

The Lower Rio Grande Valley of Texas experienced 60 hours of subfreezing temperatures during 23-26 Dec. and another 29 hours during 29-31 Dec. 1983. The impact on the Texas citrus industry has been extremely severe and long-lasting.

Estimates in 1985 indicated that only 29,000 acres (42%) survived, another 18,000 acres (26%) were dead or ahandoned, 21,000 acres (30%) had been cleared/converted to other land use and only 1,250 acres (2%) had been replanted to citrus (1,2,3). There was no commercial fruit production in the 1984-85 season. Many local growers and untold numbers of absentee owners simply gave up. Greatly reduced acreage and virtually no production caused severe economic hardship to the entire infrastructure of the citrus industry; many packers, grove care companies and agricultural chemical and equipment suppliers went out of business.

Texas Citrus Acreage—January, 1989

Rebuilding the Texas citrus industry has been much slower than anticipated, but progress has been made and Texas citrus has re-entered the marketplace. As of 1 Jan. 1989, the Texas citrus industry stands at 34,400 acres (5), which is about half the acreage present at the time of the freeze (Table 1).

Although 8,500 acres of new trees were planted between 1985 and 1987, total acreage actually declined (4). Almost 8,700 acres that were being rehabilitated in 1985 were removed by 1987. Another 4,100 acres were planted between 1987 and 1989.

Thus, the citrus industry today comprises about 12,300 acres of post-freeze plantings and 22,100 acres of pre-freeze orchards. However, new plantings (Table 1) actually total 13,850 acres, so it is assumed that the additional 1,550 acres represent either resets or intersets in older orchards, either of which create problems in conducting an inventory.

Table 1. Changes in Texas citrus acreage as a consequence of the 1983 freeze.[z]

Year	Total Acres			New plantings (acres)
	Grapefruit	Oranges	Total	
1983	44,346	24,575	68,921	—
1985	19,110	11,380	30,490	1,250
1987	18,500	11,800	30,300	8,500
1989	20,400	14,000	34,400	4,100
1989/1983	0.460	0.570	0.499	—

[z]Source: Texas Citrus Tree Inventory Survey (3,4,5).

Grapefruit. The 20,400 net acres of Texas grapefruit represents 46% of pre-freeze acreage (Table 2). 'Ruby Red' is still the major cultivar, claiming two-thirds of the acreage. 'Henderson' and 'Ray Ruby' are being distinguished from 'Ruby Red' in present inventories. It is doubtful that the enumerators could fully distinguish those cultivars from 'Ruby Red' trees with which they were grouped in the past, so the acreage of 'Henderson' and 'Ray Ruby' is probably higher than the 5.6% reported.

'Star Ruby' represents only 7% of Texas grapefruit acreage. The 4,000 acres of 'Rio Red' accounts for 20% of all grapefruit, all having been planted since 1985, as it was named and released in 1984. Perhaps not surprisingly, 'Rio Red' accounts for nearly 60% of all grapefruit planted since the freeze. There still exists a very limited acreage (3%) of white grapefruit.

Currently, 3,500 (17.2%) of the 20,400 acres of grapefruit are non-bearing and another 3,600 acres (17.6%) have not reached maturity as yet. Thus, post-freeze plantings account for just over a third of the acreage.

The average tree density is 130 trees per acre, which is a spacing of about 13.5 x 25 feet. Plantings in the last 3 years have been close to 12.5 x 25 feet, which provides 139 trees per acre. Some double-row planting configurations complicate density-spacing determinations.

Oranges. There are 14,000 net acres of oranges in Texas, which is 57% of pre-freeze acreage (Table 3). Early and mid-season varieties, principally 'Marrs', account for well over half of total acreage and 60% of all new plantings. 'Valencia' totals 31% of orange acreage, but only about 12% of new plantings, which indicates that growers have reset dead or missing trees but are not establishing new orchards of 'Valencia'.

Navel oranges have been separated from the early and mid-season category in present inventories. N33E, a local selection which developed as a bud sport of 'Marrs', is probably the principal navel orange of the several cultivars and selections present. Navels account for 13% of the acreage and 28% of new plantings, which further indicates that Texas growers are concentrating new orange plantings on cultivars that mature prior to the occurrence of most major freezes.

There are 2,100 acres of non-bearing oranges and another 3,100 acres considered young bearing, representing 15% and 22%, respectively, of the total orange acreage. Consequently, post-freeze plantings account for slightly more than a third of present orange acreage.

Table 2. Net acreage of Texas grapefruit, by age and cultivar, 1 Jan. 1989[z].

Age (yr)	Ruby Red	Henderson /Ray Ruby	Star Ruby	Rio Red	Other	Total	Average trees/acre
1-3	480	60	290	2,660	10	3,500	147
4-7	1,200	530	390	1,320	130	3,570	128
8-11	2,490	180	210	10	40	2,930	141
12+	9,060	370	540	0	430	10,400	124
Total	13,230	1,140	1,430	3,990	610	20,400	130
% of Total acreage	64.9	5.6	7.0	19.5	3.0	100.0	—

[z]Source: 1989 Texas Citrus Tree Inventory Survey (5).

Table 3. Net acreage of Texas oranges, by age and type. 1 Jan. 1989[z].

Age (yr)	Navels	Early & midseason	Valencia	Total	Average trees/acre
1-3	570	1,420	110	2,100	151
4-7	910	1,650	540	3,100	137
8-11	30	620	110	760	134
12+	350	4,110	3,580	8,040	116
Total	1,860	7,800	4,340	14,000	127
% of Total acreage	13.3	55.7	31.0	100.0	—

[z]Source: 1989 Texas Citrus Tree Inventory Survey (5).

The average planting density is 127 trees per acre, although all new plantings are at a higher density. As in grapefruit, some double-row planting configurations make it difficult to ascertain a typical spacing. However, 12.5 x 25 feet is common, providing 139 trees per acre.

The ratio of grapefruit to orange acreage has declined from 65:35 pre-freeze to 59:41 at present. This shift toward oranges may reflect grower desire to complete fruit harvest prior to the occurrence of most major freezes, although significantly lower prices for processing grapefruit as compared to processing oranges could be a major factor.

Production and Utilization

Texas grapefruit production has steadily increased to 192,000 tons (46% of pre-freeze production) in the 1988-89 season (Table 4.) Orange production has also increased, but only to 78,625 tons (33% of pre-freeze production) in 1988-89. Official USDA crop estimates for the 1989-90 season are 176,000 tons of grapefruit and 82,875 tons of all oranges, down 8% and up 5%, respectively, from the previous season. This deviation from the trend is mainly due to a light freeze in early February and another in early March, 1989.

The fact that 46% of pre-freeze grapefruit acreage achieved 46% of pre-freeze average (PFA) production implies that grapefruit orchards are fully recovered from the freeze. However, the PFA production for grapefruit is probably lower than actual, inasmuch as an unknown tonnage of grapefruit was not harvested in the last 2 of the 5 seasons used for the average. Incomplete harvest occurred because of a large inventory of processed product and very low prices for processing grapefruit. Consequently, Texas grapefruit orchards are no more than a season or so from full recovery.

Orange orchards have not fared so well as grapefruit, as 57% of pre-freeze acreage produced only 33% of PFA. The proportion of non-bearing and immature orange orchards is little different from that for grapefruit, so it is apparent that oranges are still a couple of seasons from full recovery.

Fruit quality has been excellent, as indicated by the higher proportions of both grapefruit and oranges that have been used fresh (Table 4). Reduced supplies and higher fruit quality have kept prices high, as the 1988-89 crop was worth $85.7 million, which is comparable to pre-freeze values.

Two important changes in Texas citrus marketing in the last year should improve the position of Texas citrus in the marketplace. The industry is now marketing its fruit as Texas Fancy (an improved U. S. No. 1 grade) and Texas Choice (an improved U. S. No. 2 grade). Moreover, grapefruit is being marketed under the patented names of Ruby-Sweet and Rio Star. Ruby-Sweet includes 'Ruby Red', 'Henderson', 'Ray Ruby' and similar red grapefruit, whereas Rio Star includes 'Rio Red' and 'Star Ruby'.

Summary and Conclusions

The Texas citrus industry was projected to reach 50,000 acres by 1987-88 (1,2), yet only 34,400 acres exist presently (5). Several factors combined to delay the potential recovery. Most significant of these factors was the removal of an additional 8,700 acres of trees following the 1985 inventory. Those orchards were lost to additional freeze damage in 1985 and economic problems with negative cash flow.

The projected recovery was based upon citrus nursery inventories (3) and assumptions that proved faulty. Nurserymen expected to deliver enough trees to plant 25,000 acres in 2 to 3 years, but they actually delivered only about 16,000 or so (including resets) in the succeeding 4 years. Additional freeze damage to nurseries and budwood sources in 1985 was partly responsible, but of more significance was the unexpectedly lower proportion of plantable trees per quart of seed planted.

Table 4. Texas citrus production and utilization since the 1983 freeze, with production comparisons to pre-freeze averages (PFA)[z].

	Grapefruit			Oranges					
				Early & mid-season			Valencia		
Season	Toms[y]	Fresh[x] (%)	% of PFA	Toms[y]	Fresh[x] (%)	% of PFA	Toms[y]	Fresh[x] (%)	% of PFA
PFA	418,000	58	100	148,750	46	100	85,000	44	100
1984-85	0	—	—	0	—	—	0	—	—
1985-86	8,800	91	2.1	8,500	94	5.7	4,675	93	5.5
1986-87	77,000	81	18.4	21,250	92	14.3	15,950	87	18.8
1987-88	152,000	73	36.4	39,950	89	26.9	20,825	89	24.5
1988-89	192,000	81	45.9	51,000	85	34.3	27,625	84	32.5
1989-90[w]	176,000	—	42.1	55,250	—	37.1	27,625	—	32.5

[z]PFA is the average production and utilization for the 5 seasons ending with 1982-83.
[y]A ton of grapefruit equals 23.53 Florida boxes, a ton of oranges equals 22.22 Florida boxes.
[x]Fresh utlization is all non-processed uses, including domestic and export shipments, gift fruit and local use.
[w]USDA crop forecast, 12 Oct. 1989.

Moreover, the overall average tree density has increased by about 11%, as post-freeze plantings have averaged about 20% more trees per acre. At pre-freeze densities, nursery production could have planted another 3,000 acres.

With respect to future projections, the Annual Citrus Nursery Stock Survey (5) reports that 645,000 citrus trees were to have been delivered between 1 Jul. 1988 and 30 Jun. 1989. Approximately, 63% are grapefruit and nearly 53% are 'Rio Red'. In addition, there were approximately 1,300,000 rootstocks (seedbeds and unbudded liners) in Jul. 1988.

At present planting densities, the 645,000 new trees should establish about 4,500 acres. It should be noted that the nursery survey is conducted annually on 1 Jul., whereas the tree inventory is conducted biennially on 1 Jan. Consequently, an undetermined number of the 1988-89 new trees produced were already planted—and thereby counted—in the 1989 inventory.

Although the recovery of lost acreage is taking longer than expected, most observers still consider 50,000 total acres to be about the maximum acreage for the future. At present average planting rates of about 2,500 acres per year, it will take another 5 or 6 years to reach that level.

Despite the slower recovery, the outlook for the Texas citrus industry is extremely bright. Future production will be from vigorous, new plantings and some of the better orchards that are rehabilitated. Better quality, higher grades and the new market names to reflect the traditional Texas red grapefruit and the newer "super-reds" should assure good returns for Texas citrus in the years ahead.

AUTHORS' UPDATE
December 1989 Freeze Update

Since presentation of this manuscript, the Texas citrus industry was hard hit by another major freeze during 22-24 Dec. 1989. Subfreezing temperatures existed for about 50 hours, with over 7 hours at below 20°F and about 22 hours in the low-to-mid-twenties. Essentially, 60 percent of the grapefruit crop, 30 percent of early and midseason oranges and all 'Valencia' fruit were still on-tree and frozen, although some juice salvage operations were continued as long as possible.

Trees were considered to have very good cold hardiness because of a dry year without leaching rainfall to remove excess salts and because of a much colder than normal December preceding this freeze. Some bark splitting has been observed, but not to the extent as in earlier freezes. Bark cutting has revealed grey-brown cambial areas in grapefruit wood to 2-inch diameter. However, conclusions as to overall tree damage and recovery potential will not be realistic until a couple of months after the 1990 spring flush.

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Proc. Fla. State Hort. Soc. 102:75-78. 1989.

YIELD AND FRUIT QUALITY OF 'AMBERSWEET' ORANGE HYBRID ON DIFFERENT ROOTSTOCKS

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Addition index words. Citrus scion, pollenizer

Abstract. **'Ambersweet' is a hybrid of (*Citrus reticulata* Blanco x (*C. paradisi* Macf. x *C. reticulata*)) x midseason orange, *C. sinensis* (L.) Osb., developed in the USDA breeding program. Fruit can be harvested in central Florida for the fresh market from mid-October through December. Fruit for processing can be harvested from mid-November through December. The fruit resemble those of navel orange in size and appearance more than other types and have orange rind color at maturity. The rind can be removed easily and the juice has dark-orange color at maturity. The trees are vigorous, have a dense canopy, and are moderately cold hardy. Trees perform equally well on Cleopatra mandarin (*C. reticulata*), sour orange *C. aurantium* L.), and Carrizo citrange (*C. sinensis* x *Poncirus trifoliata* (L.) Raf.) rootstocks. Fruit yields are good on rough lemon (*C. limon* (L.) Burm. f.) rootstock, but fruit quality is less desirable than on other rootstocks. The fruit can be picked without clipping and with little rind plugging. Ambersweet fruit store well at 34° and 70°F, as do oranges.**

Origin and Description

'Ambersweet' resulted from a 1963 cross of 1-3-54 (Clementine tangerine x Orlando tangelo) x 15-3 seedling midseason sweet orange made by C. J. Hearn and P. C. Reece at Ft. Pierce, Florida.'Ambersweet' was selected in 1972 from 712 seedlings grown from the cross at the A. H. Whitmore Foundation Farm. Trees were grafted to 4 rootstocks in 1973, and the grafted trees were established in field tests in 1974 near Leesburg and Lake Wales, as selection 1-100-29, until 'Ambersweet' was released in 1989 by the Agricultural Research Service, U. S. Department of Agriculture.The parent tree of 'Ambersweet' was indexed for virus diseases in 1974, and was found positive for tristeza. Since the 15-year-old trees on sour orange rootstock appear healthy in 1989, it is likely that the tristeza virus is a mild strain.