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EFFECTIVENESS OF SCAFFOLD BRANCH IRRIGATION FOR FREEZE PROTECTION OF LOUISIANA CITRUS DURING 1989 FREEZE

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Abstract. **During the Dec. 1989 freeze, a scaffold branch irrigation freeze protection system was in operation on 5-year old 'Washington' navel and 'Owari' satsuma trees and several younger trees of various navel orange varieties, a cold tolerant satsuma selection and other navel orange trees at the LSU Citrus Research Station in Port Sulphur, Louisiana. Temperature dipped to a low of -11.1°C with 20 consecutive hours of -6.7°C or below, and 80 consecutive hours of 0°C or lower.**

Post-freeze evaluations and ratings show that an average tree survival rate of 94.6% was obtained. An average of 84.6% survival of scaffold branches and an average of 11% canopy survival was also achieved through the use of scaffold branch irrigation for freeze protection. Trunk injury ratings averaged 8.8 (Rating scale 0-10; 0 = Dead 10 = No injury) and shoot regrowth after pruning dead wood averaged 8.0 (Rating scale 0-10; 0 = No shoot regrowth, 10 = Excellent shoot regrowth). The average percentage of tree regrowth was slightly above 80% of the original tree volume prior to the freeze. Nonprotected trees sustained 100% kill and necessitated removal and reestablishment. Scaffold branch irrigation performed well during the severe freeze experienced in 1989 and offers an alternative to citrus growers for protection from the ravages of frequently reoccurring freezes.

The use of microsprinklers to protect citrus trees from freezing has received a considerable amount of attention in recent years. Several investigators (1-17) have reported on the benefits of the use of sprinkler irrigation for citrus freeze protection during the advent of a severe freeze. Bourgeois et al. (2) showed that low.volume sprinkler irrigation increased the mean trunk, scaffold limb and canopy temperature 4.6, 0.6 and 0.8°C respectively, higher than nonirrigated trees of 'Washington' navel orange and a similar increase in temperature of 3.9, 1.7 and 0.9°C respectively was obtained in these same locations on 'Owari' satsuma trees. Parsons et al. (16) showed that air temperature was generally 0.5 to 1.5°C warmer in an irrigated area above the spray than in the nonirrigated area.

Based on these results and those of other investigations, several plantings at the Citrus Research Station were equipped with the scaffold branch freeze protection system with plans to operate the system in the event of a severe freeze as was the case in 1989.

The Arctic outbreak of Dec. 1989 was the first to occur in Louisiana since the record setting outbreak of Jan. 1985. Cold air began entering the state on 21 Dec. 1990 and by the morning of 22 Dec. the temperature was below freezing throughout the state. The coldest temperatures were recorded on 23 Dec. when the temperatures ranged from -17.8°C in the northern part of the state to -13.3°C at Baton Rouge and to -11.1°C at the Citrus Research Station in southeastern Louisiana (R. Edling, Louisiana State University personal communication). Total number of hours below freezing ranged from 130 hours in north Louisiana to approximately 80 hours in the southeastern part of the state, and the number of consecutive hours below -6.7°C reached approximately 20 hours (Fig 1).

During the Dec. 1989 freeze, a scaffold branch irrigation system developed for freeze protection was in operation on various citrus test plots at the Citrus Research Station in Port Sulphur, Louisiana. This report is an evaluation of the results obtained during and after this severe freeze.

Materials and Methods

Scaffold branch irrigation for freeze protection was in operation on five-year old 'Washington' navel orange and 'Owari' satsuma trees on *Poncirus trifoliata* Rubidoux rootstock with 48 trees at each site at the Citrus Research Station in Dec. 1989. Each tree was equipped with a Senninger 360° Super Spray sprinkler with a # 8 tip [3.18 mm 1/8") diameter opening] and a smooth, flat deflector, which is capable of applying 5.7 liters·min^{-1} (90 gal/hr) at 69 kPa (10 psi). Other locations of freeze protection consisted of an area of 13 navel orange varieties on *P. trifoliata* Rubidoux (160 trees) which were 2.5 years old, an area of a cold-tolerant satsuma selection (4—40) on *P. trifoliata*

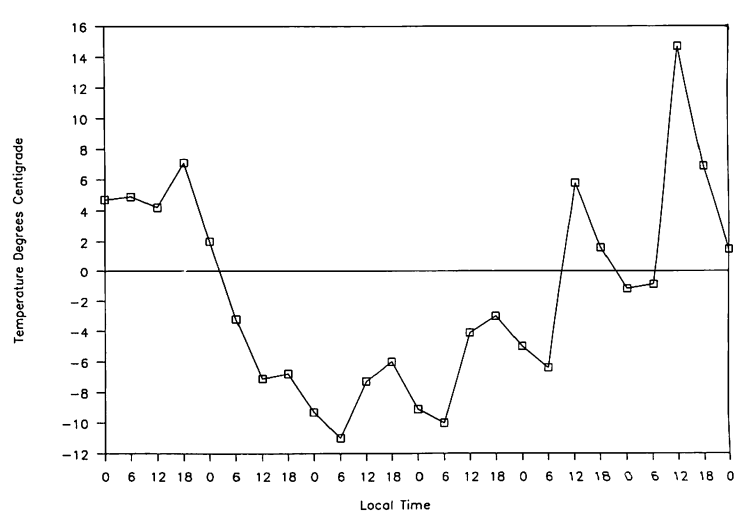

Fig. 1. Air temperature — Citrus Research Station 21 Dec-26 Dec 1989.

Rubidoux consisting of 128 four-year old trees and an area of 134 four-year old 'Washington' navel trees on *P. trifoliata* Rubidoux. Trees at these 3 locations were equipped with a Senninger 360° Super Spray sprinkler with a # 5 tip [1.99 mm (5/64") diameter opening] and a smooth, flat deflector which is capable of applying 1.9 liters·min^{-1} (30 gal/hr) at 69 kPa (10 psi). These sprinklers were mounted approximately .75 –1 m above the soil surface and in the scaffold branches area of each tree.

Post-freeze evaluations were begun approximately 2 months (Feb. 1990) after the freeze by measuring the height and diameter of the trees in order to determine the initial canopy volume of each tree prior to the freeze. Upon completion, the surviving trees were hand pruned by cutting back the twigs and branches to visible live wood. Once this procedure was completed the trees were again measured for height and diameter to determine the amount of canopy survival for the freeze-protected trees. Also at this time the trees were rated for trunk injury (Rating scale 0 - 10; 0 = Dead, 10 = No injury), percent scaffold branch survival (visually estimating the percentage of scaffold branch survival) and regrowth (Rating scale 0 - 10; 0 = No regrowth, 10 = Excellent regrowth). The surviving trees were maintained under normal orchard management procedures as to fertilization, insect control, disease control, weed control and other standard practices.

Nine months after the surviving trees were pruned th trees were again measured for height and diameter to determine the volume of regrowth that had occurred. This calculation was used to determine the percentage of regrowth present as compared with the initial size of the trees prior to the Dec. 1989 freeze.

Results and Discussion

The results of the post-freeze evaluation of the scaffold branch freeze protection system are shown in Table 1. The trunk injury ratings averaged 8.8 and ranged from a high of 9.5 to a low of 7.9. Both satsuma test locations had the highest rating for trunk injury with 9.5 and 9.2, respectively, for the satsuma selection 4-40 and 'Owari'. The navel orange test areas had trunk injury ratings equal to or slightly lower than the average.

The percentage of scaffold branch survival average 84.6% and had a range of 89.7 to 78.5%. Again both satsuma varieties showed the greatest scaffold branch survival. Also, the navel orange trees had equal to or slightly lower than average percentages of scaffold branch survival.

Both factors of trunk injury and scaffold branch survival are important in the regeneration of the tree upon removal of dead wood after the occurrence of a severe freeze. If a considerable amount of the basic tree structure remains intact with a minimal amount of damage, then the tree regenerative process can proceed at a rapid pace and production can resume in a relatively short period of time. Based on the results obtained of the slight or minor trunk injury rating and the relatively high percentage of scaffold branch survival, the freeze-protected trees were able to regenerate quite rapidly, especially the satsuma trees, which had a limited amount of fruit set during the 1990 production season.

Another factor evaluated was that of the percentage of canopy survival (Figure 2). The average percentage of canopy survival was 11% with a range of 15.3 to 6.9%. Even though the percentage is relatively low, rapid regrowth and canopy regeneration can occur once the dead wood has been pruned. This is evident in the average percentage of regrowth obtained which was 80.1%. The average percentage of regrowth ranged from 116.8% for the 4–40 satsuma selection to 54.5% for the older 'Washington' naval orange trees. The results indicate that trees under scaffold branch irrigation for freeze protection survive the ravages of a severe freeze and in turn regenerated to approximately the original tree size prior to the freeze, and in the case of the satsuma selection 4-40 greater than the original size, thus indicating that this variety has some cold tolerance.

The average tree survival nine months after the 1989 freeze was 94.6%. This high percentage of tree survival reenforces the previous claim that scaffold branch irrigation is a viable method of citrus freeze protection. The critical factors, which became evident during and after the operation of this system during a severe freeze, were the

Table 1. Post freeze evaluations of citrus trees under scaffold branch irrigation freeze protection at the Citrus Research Station.

Location	Application Rate (liters/min)	Average Trunk[z] Injury	Scaffold Branch Survival	Canopy[x] Survival	Regrowth
			%	%	%
Owari Satsuma	5.7	9.2	85.8	15.3	74.0
Wash Navel	5.7	8.6	84.0	10.8	53.4
Navel Varieties	1.9	7.9	78.5	6.9	85.2
4-40 Satsuma Selection	1.9	9.5	89.7	14.4	116.8
Wash Navels (Density)	1.9	8.8	84.8	7.5	70.9

[z]Rating scale 0 - 10; 0 = Dead, 10 = No injury
[x]Canopy volume calculated using the formula: $V = 0.5236HD^2$; Where: V = Canopy Volume, H = Height, and D = Diameter.

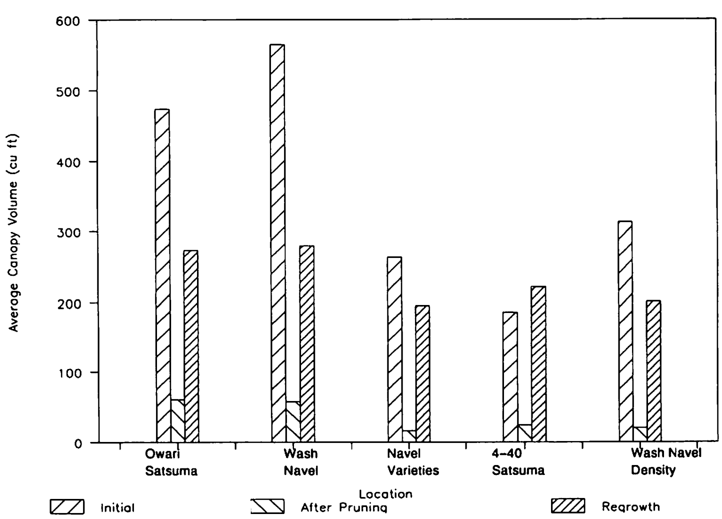

Fig. 2. Comparison of canopy volume of citrus trees under scaffold branch irrigation freeze protection at Citrus Research Station after 1989 freeze.

placement of the sprinkler head and the amount of water delivered from that sprinkler. Improper placement could lead to severe trunk damage and loss of the all important scaffold limbs and diminish the usefulness of this system. Therefore, extreme care should be taken in the installation and placement of the sprinkler head as to afford the highest degeee of effectiveness. Equally important is the volume of water supplied by the sprinkler head. It is recommended that 1.9 to 5.7 liters·min^{-1} (.5 - 1.5 gal/min) be supplied to the scaffold branch area of the citrus tree during the advent of a severe freeze. The information accumulated during and after the 1989 freeze supports the conclusion that scaffold branch irrigation is a viable system for citrus freeze protection.

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FREEZE DAMAGE SUSTAINED BY 27 CITRUS CULTIVARS ON 21 ROOTSTOCKS IN THE BUDWOOD FOUNDATION GROVE, IMMOKALEE

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Abstract. **Trees 6 and 8 months after field planting experienced temperatures of 24° on 24 & 25 Dec. 1989. Ratings of freeze damage showed differences among scion cultivars and scion/rootstock combinations. 'Star Ruby' grapefruit (*Citrus paradisi* Macf.) and 'Fallglo' citrus hybrid, a cross of Bower mandarin citrus hybrid x 'Temple' tangor, (*C. temple* Hort. ex Y. Tanaka) were the most severely damaged scion cultivars. 'Rohde Red' Valencia orange selection 472-11-43 [*C. sinensis* (L.) Osbeck] was the least damaged scion cultivar. Scions budded to Cleopatra mandarin (*C. reshni* Hort. ex Tan.) and F-80-18 citrumelo [*C. paradisi* x *Poncirus trifoliata* (L.) Raf.] rootstocks were damaged more than scions on other rootstocks. Scions budded to Smooth Flat Seville (*C. aurantium* ?) and *P. trifoliata* x Ridge pineapple sweet orange selection 1573-26 (*C. sinensis* (L.) Osbeck] showed the least damage.**

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Visually assessing injury to plants following naturally occurring cold temperatures has long been the basis for determining their relative cold tolerance. Although a general ranking of cold tolerance has been established among most citrus cultivars, the specific ranking can vary considerably when evaluating results following natural freezes primarily because citrus cold hardiness is dependent upon climatic conditions prior to the period of freezing temperatures, and other factors (5). Cold hardiness of citrus is closely associated with dormancy. Trees that are dormant and have been exposed to low but not freezing temperatures for some time often exhibit the most cold hardiness (5). Observations over many years and freeze events indicate that in Florida, mandarins, 'Orlando' tangelo and 'Hamlin' orange are the most cold-tolerant scion cultivars. In descending order these are followed by 'Valencia'