Table 1. Projected expenses and time involved in ground surveys and aerial color infrared (ACIR) photography of citrus groves.

Ground survey	ACIR
I. First year's estimated costs	I. First year's estimated costs
A. Two appraisers and clerk	A. One appraiser
B. Survey vehicle operation and maintenance	B. Video system
	C. Computer program
C. Calculator, expendable materials, graph paper	D. ACIR film
	E. Expendable material
Total cost $21,000	Total cost $8,500
II. Second year's estimated costs	II. Second year's estimated costs
A. Labor and expenses would be approximately the same as the first year's.	A. Interpretation and film costs were same as the first year's.
B. Additional operation and maintenance of the survey vehicle required.	B. Minor maintenance of video equipment.
Total cost $21,000	Total cost $6,700
III. Third year's estimated costs	III. Third year's estimated costs
A. Labor and expenses would be approximately the same as the first year's.	A. Interpretation and film costs were same as the first year's.
B. Additional operation and maintenance of the survey vehicle required.	B. Minor maintenance of video equipment.
Total cost $21,000	Total cost $7,000
IV. Three-year costs for ground survey Labor, expendable materials, and cost of survey vehicle $63,000	IV. Three-year costs for ACIR Intrpretation, film, video system and expenses $22,000
V. Two Appraisers and a Clerk were assigned to Ground Survey for a total of 24 months.	V. One appraiser was assigned to V. the ACIR survey for 24 weeks each year.
VI. There were no cost savings.	VI. Potential savings in 3 years of VI. $41,000.

Comparison of the man-hours and equipment requirements between the 2 survey methods suggested that there would be considerable cost benefits in counting trees with ACIR photography (Table 1). However, actual dollar cost savings were difficult to establish because savings in personnel and equipment could not be charged to a specific account. The survey vehicle already belonged to the Appraiser's office, and the citrus appraisers were already on the payroll. In a commercial environment, cost comparisons could have been more easily calculated (7). Even so, with the above limitations, potential cost savings to the county could be estimated (Table 1). The major cost savings of ACIR were: 1) only 1 appraiser instead of 2 was required, and 2) survey time was reduced from 24 months to 24 weeks. Total potential cost savings to the county over the 3-yr survey period was estimated to be $41,000.

Input of photointerpretation data into a terminal was a faster method of counting trees from aerial photographs, and worked well for the small citrus acreage found in Charlotte County. This system would probably require more development in counties with larger citrus acreage like Polk or Highlands. The results obtained for Charlotte County during the past 4 yr suggest that the development of an automatic tree counter and photointerpreter could accelerate data acquisition and input into a computer. Property appraisers, large grove operations, and other interested parties would then be able to more rapidly obtain tree counts and establish property values in a more timely manner.

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THE PROPAGATION OF CITRUS ROOTSTOCKS BY STEM CUTTINGS

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Abstract. **When seed of desired citrus rootstocks is not available in sufficient quantities, rootstocks can be propagated as stem cuttings. Rooting hormones, leaf area, maturity of the stock plants and propagation environment are among the important factors affecting the rooting of citrus cuttings. In experiments with Swingle citrumelo (*Citrus paradisi* Macf. × *Poncirus trifoliata* (L.) Raf.), 6-inch cuttings were rooted in a 1:1 peat:perlite mixture in styrofoam trays under intermittent mist in a greenhouse. Evaluations after 6 weeks revealed that juvenile 3-leaf cuttings produced more roots than mature 3-leaf cuttings. The leaf area of mature cuttings but not of juvenile cuttings affected root production. Indolebutyric acid and napthaleneacetic acid, both at 3000 ppm, stimulated the greatest root production in juvenile and mature cuttings, respectively.**

Recent freezes in Florida have limited the supply of rootstock seed and created interest in the propagation of

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rootstocks and even scion cultivars by stem cuttings. The purpose of this paper is to summarize relevant information on the propagation of citrus rootstocks by stem cuttings and to present data on the rooting of Swingle citrumelo by stem cuttings.

Large numbers of clonal rootstocks are needed to produce the 14-20 million commercial trees propagated by citrus nurserymen every year in Florida. These rootstocks can be produced by using seeds from nucellar rootstock selections, by micropropagation in tissue culture, or by the use of "own-rooted citrus" via cuttings or marcots.

Own-rooted citrus. Own-rooted citrus generally refers to the propagation of citrus by layers or cuttings. Marcottage or air layering is used in tropical and subtropical regions to propagate citrus and other fruit crops. Stem cuttings are used to propagate citron in Mediterranean countries, ornamental citrus in the United States, and to produce citrus rootstocks when seed is unavailable (12). Citrus rootstock and scion selections are also propagated for experimental work by cuttings and layers when desired species have low seed viability, few seeds per fruit, or a low degree of nucellar embryony. Twig grafting in which a scion cutting may be grafted onto a rootstock cutting, leaf bud cuttings involving a stem cutting with only one bud, and even leaf cuttings without stem tissue have also been used on a limited scale. While considerable differences can exist in the rooting of stem cuttings among genera and species, within species, and even within clones of the same species, emphasis will be placed on general principles of rooting citrus stem cuttings.

Selection of propagation material. Although softwood cuttings have been used (13), propagation material is usually taken from recently matured, terminal growth or semi-hardwood of healthy, well-fertilized, vigorous trees. These trees should be free of frost damage, insect damage and diseases (especially viruses and citrus bacterial canker). Avoid trees that have recently been sprayed with oil since defoliation of cuttings can occur in the propagation bed. Cuttings are usually made during the summer months from the growth flush of the previous spring. However when several flushes occur each year, cuttings may be taken after the flush has hardened. Cuttings should be taken early in the day when leaves are turgid. Observations on the rooting of stem cuttings of many different genera of plants indicate that better regeneration of roots occurs when cuttings are taken either before or after, but not during, flowering (4).

The nutrition of the stock plant can strongly affect the development of roots from stem cuttings and is generally associated with the carbohydrate/nitrogen balance (8). Young succulent stems, high in nitrogen but low in carbohydrates, generally root poorly, but recently matured stems, high in carbohydrate and low in nitrogen, root well. The retention of leaves on cuttings can also affect the accumulation of carbohydrates at the base of the cuttings, thereby affecting rooting. Girdling the stem can block the downward movement of carbohydrates, hormones and other root-promoting factors. Rooting of citrus cuttings was increased by girdling the shoots with wire from several days to several weeks before cuttings were taken (2, 9). Phosphorus nutrition of the source tree can also affect rooting of citrus cuttings (6).

Juvenility. In general, juvenility is associated with lack of flower and fruit production, thorniness and a vigorous, upright growth habit. Stem cuttings taken from juvenile plants develop new roots more readily than cuttings taken from mature plants. Furthermore, cuttings from young seedlings tend to produce roots that grow downward; cuttings from extremely young seedlings can form tap roots similar to those developed by plants grown from seed. Cuttings from mature trees tend to produce roots that grow laterally (10).

Ease of rooting. Lemons, limes and citrons root readily within 4 to 6 weeks; sweet oranges, sour oranges, grapefruit, trifoliate orange and citranges are intermediate, rooting with 6 to 8 weeks; mandarins are considered to be the most difficult to root and may take up to 16 weeks (10).

Growth regulators and fungicides. Indolebutyric acid (IBA) and napthaleneacetic acid (NAA), both auxins, can: 1) increase the percentage of cuttings that form roots, 2) hasten the initiation of roots, 3) increase the number and quality of roots produced per cutting, and 4) increase uniformity of rooting. There may be considerable variability in the rooting response of different citrus rootstocks to treatment with these hormones. IBA is frequently used in concentrations of 3,000 to 10,000 ppm depending on the ease of rooting of a particular rootstock. Sucrose in combination with IBA has also increased rooting of citrus cuttings (11). During and immediately after rooting, cuttings may be susceptible to a number of soil-borne pathogens. Treatment with fungicides can improve both root survival and quality.

Temperature, light and humidity. Ambient and soil temperatures of 75 to 90F stimulate rooting (5, 7), but higher soil temperatures may be necessary for species that are difficult to root (1, 7). Ambient temperatures greater than 95F may cause wilting and burning of leaves. When bottom heat and/or steam heat is used during the winter months to maintain minimum temperatures in the greenhouse, leaf drying and subsequent drop may occur. Intermittent misting for full 24 hour periods may be required to maintain leaf turgidity (1). However, such continual misting could lead to disease and leaching problems. Radiant-heated benches, utilizing ¾ inch copper pipes embedded in concrete to circulate hot water, have also been used to provide bottom heat to root citrus cuttings (3).

Although little research has been done on the effects of light intensity, photoperiod or light quality on rooting of citrus cuttings, the general practice is to root cuttings under high light intensity in the greenhouse during the summer and fall.

During the rooting of stem cuttings, leaves continue to lose water through transpiration. If too much water is lost, leaves will wilt before new water-absorbing roots can form. Humidity should be maintained at a high enough level to minimize leaf transpiration. High humidity environments can be maintained within glass or polyethylene-covered propagating frames in the greenhouse or the field. However, temperature control may be a problem in these structures. Greenhouse mist systems can reduce leaf temperature, thereby reducing transpiration, without reducing light intensity. Periodic misting applied only during the day at frequent, short intervals can provide enough water to keep leaves wet yet not saturate the growing medium. However, in some situations, nutrients may have to be added to the mist to replenish nutrient elements lost through leaching.

After the roots have grown 4 to 8 inches, cuttings may be hardened-off by gradually reducing the humidity in the propagation frame or mist house. When mist systems are used, the misting period can be reduced until cuttings no longer require moisture on leaves to prevent wilting.

Rooting media. A number of materials, including field soil, sand, peat moss, shredded sphagnum moss, vermiculite, perlite, pumice, synthetic rooting blocks and aerated water, have been used. However perlite or a 1:2 to 1:3 peat moss/perlite mixture is commonly used for leafy cuttings. Ford (5) found a 1:1 mixture of peat and perlite best for rooting rough lemon cuttings. When peat is used in a rooting medium, adequate drainage must be provided. Re-used propagation media should be sterilized before a second planting.

Materials and Methods

During August, 6-inch semi-hardwood cuttings were taken from the terminal growth of Swingle citrumelo seedlings and mature trees. Basal leaves were removed and cuttings with 3 or 6 terminal leaves were prepared. All cuttings were dipped for 3-5 minutes in solutions of benomyl and ethazol (Truban), each at a concentration of 1 ounce/10 gallons. Cuttings were dipped in a 50% alcohol solution as a control treatment, IBA (3000 ppm), NAA (3000 ppm) and Hormodin #2 powder, a commercial preparation containing IBA (3000 ppm). Cuttings were then placed in 6-inch deep styrofoam Speedling (Speedling, Inc., Sun City, FL 33586) trays containing a 1:1 mixture of peat and coarse perlite. Intermittent mist was applied for 15 seconds every 30 min during the day only. Ambient air and soil temperatures ranged from 70 to 90F. The 16 treatments were arranged in a completely randomized design with 12 replications per treatment (8 observations per replication). Data were analyzed as 2 × 2 × 4 factorial experiment involving tree maturity, leaf number per cutting and hormone treatment. Cuttings were harvested 6 weeks after planting and evaluated for percent cuttings rooted, number of roots per cutting and weight per cutting.

Results and Discussion

Significant interactions occurred between tree maturity and leaf number per cutting in terms of the number of roots produced per cutting and root weight per cutting but not the percentage of cuttings that rooted. The number of roots produced per cutting was significantly greater for juvenile 3-leaf cuttings than for mature 3-leaf cuttings. There were no differences in root production between juvenile 6-leaf and mature 6-leaf cuttings or between juvenile 3-leaf and juvenile 6-leaf cuttings but there were significant differences between mature 3-leaf and mature 6-leaf cuttings (Table 1). The same patterns occurred with root weight per cutting (Table 2).

Stem cuttings from juvenile trees are generally recommended over stem cuttings from mature trees for propagation of own-rooted citrus. When Swingle citrumelo is used, our data indicated that only juvenile cuttings with a small leaf area produced more roots than mature cuttings with the same leaf area. Furthermore, leaf area of juvenile cuttings did not affect root production, but leaf area on mature cuttings did.

Table 1. The effect of tree maturity and leaf number per cutting on root production of Swingle citrumelo stem cuttings.[z]

Tree maturity	Root (no. per cutting)		
	3	6	6-3[x]
Juvenile (J)	3.42	3.52	0.10
Mature (M)	3.14	3.72	0.58[w]
M-J[y]	−0.28[w]	0.20	

[z]Significant interaction according to the F test, 5% level.
[y]Simple effect of tree maturity.
[x]Simple effect of leaf number per cutting.
[w]Mean separation according to the t test significant at the 5% level.

Table 2. The effect of tree maturity and leaf number per cutting on weight of Swingle citrumelo stem cuttings.[z]

Tree maturity	Weight per cutting (g)		
	3	6	6-3[x]
Juvenile (J)	0.56	0.61	0.05
Mature (M)	0.45	0.60	0.15[w]
M-J[y]	−0.11[w]	0.01	

[z]Significant interaction according to the F test, 5% level.
[y]Simple effect of tree maturity.
[x]Simple effect of leaf # per cutting.
[w]Mean separation according to the t test, significant at the 5% level.

Table 3. The effect of tree maturity and hormone treatment on root production of Swingle citrumelo stem cuttings.[z]

Treatment	Juvenile	Mature
	Root no. cutting	
Control	3.23 b[y]	3.09 c
Hormodin (3000 ppm IBA)	3.29 b	3.23 c
IBA (3000 ppm)	3.80 a	3.46 b
NAA (3000 ppm)	3.56 ab	3.93 a

[z]Significant interaction according to the F test at the 5% level.
[y]Mean separation within columns by Duncan's multiple range test at the 5% level.

Significant interactions also occurred between tree maturity and hormone treatments. Both IBA and NAA stimulated greater root production in juvenile cuttings than did Hormodin or the control treatment. However, root production in juvenile cuttings treated with IBA was statistically greater than in cuttings treated with NAA. In contrast, NAA stimulated the greatest root production in mature cuttings (Table 3).

Current interest in the propagation of citrus rootstocks and scion cultivars by rooting of stem cuttings should stimulate further experimentation in this area by both researchers and nurserymen. Since there is considerable variability in the rooting of stem cuttings of different citrus species, large-scale propagation should not be attempted until the best procedures for producing rooted stem cuttings of specific species have been determined.

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MINIMUM TEMPERATURE CYCLES IN FLORIDA

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Abstract. **Time series formed from 88 years (1898-1985) of minimum temperature observations from Jacksonville, Ocala, Clermont, Bartow, Arcadia, Fort Myers, and Miami, and 151 years (1835-1985) of annual minimum temperatures from Jacksonville were analyzed. Trends, patterns, and possible cycles and periodicities of the time series were identified. Linear correlations among the seven stations were calculated to determine the change of minimum temperatures with latitude and distance to coast. Our present position in the time series is compared to similar situations in the past to infer possible future minimum temperatures.**

Extreme low temperature events have large negative impacts on horticulture. Extreme events which occur back to back are even more devastating. An example is the 25 Dec. 1983 freeze (8) which was followed 13 months later by the 21 Jan. 1985 freeze (9). Four severe freezes occurred during the past 5 winters (1980-81 to 1984-85); the one winter without a severe freeze was the 1982-83 season. This recent cluster of freezes raised questions concerning possible short-term changes in the temperature regime in the Florida peninsula. Historical observations appeared to indicate that these events tend to occur in cycles and with some periodicities (5). Citrus products (fresh fruit and juice) were exported from the St. Augustine area as early as 1778 (6, 20). Many trees in the area were 100-years-old (7) when the freeze of 7-8 Feb. 1835 struck—" .. there came a frost, a killing frost, which destroyed every orange, lime, and lemon tree in Florida, a circumstance which could not have been foreseen, as such a thing had never before occurred . . ." (7). The point is there was a period of some 50-100 years where minimum temperatures were mild enough to support citrus cultivation in the St. Augustine area. Then 2 back-to-back freezes (27-28 Dec. 1894 and 7-10 Feb. 1895) occurred. They " .. destroyed more property than any other freeze in the history of the state . . ." (5, 16). The freeze of 1899 (Jacksonville minimum temperature, −12°C) killed many trees in north central Florida and was instrumental in movement of groves southward. Next came the 11 and 13 Dec. 1962 freeze, which was recorded as the most severe freeze of this century (10) until another pair of freezes occurred on Dec. 1983 and Jan. 1985. Thus, available historical records of citrus culture indicate at least 3 periods of 60 to 70 years in the recent past when the temperature environment was supportive to citrus cultivation in north central Florida: the St. Augustine area (pre 1835), the Palatka area (1835-1899), then movement southward (post 1899). Now there is doubt about citrus cultivation in Marion County.

This study analyzes the long term records of absolute minimum temperatures in Florida for 7 cities in interior and coastal locations. The purpose is to identify trends and periodicities for short term prediction and future planning. Analyses were done on the long term annual data from Jacksonville, and statistical correlations were employed to show the change of minimum temperature in the peninsula. Seasonal minimum temperatures were selected for this study because of their critical importance to horticulture. Some points in the time series may reach the observed value for as little as 1 to 2 hours out of the entire season (1 Nov. to 15 Mar.) or the annual calendar year (1 Jan. to 31 Dec.).

Materials and Methods

Time series formed from absolute seasonal minimum temperatures (1898-1985) from Jacksonville, Ocala, Clermont, Bartow, Arcadia, Fort Myers, and Miami were analyzed. In addition, a longer period (151 years) of annual minimum temperature (1835-1985) from Jacksonville were also used. The cities were selected on the basis of the length and completeness of their temperature records and their locations in the peninsula to give spatial and coastal representation. The annual data from Jacksonville were compiled from 1835-1905 (14) and from Climatological Data for Florida (4). Data before about 1897 were deemed reliable but unofficial. Seasonal data are more suitable for analysis because the annual accounting method separates observations in a season into 2 calendar years. A long series

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