dichlorophenoxyacetic acid (2,4-D) will prevent excessive drop when fruit is held so late that drop becomes a problem and that gibberellic acid (GA) will delay senesence of the peel. Such fruit become undesirably large and the late harvest will, of course, affect the following crop. Trees were not spot picked, however, in this research (4). Our results with spot picking the largest sizes early suggest the grower might be able to harvest the larger sizes early, thereby taking advantage of the generally higher early-season prices, and hold the remaining fruit on the tree into the off-season with a spray of 2,4-D and GA. The small fruit that remained should not become undesirably large and the exhaustive effects on the following crop would be reduced. Research to determine the performance of grapefruit handled in this manner is underway, along with research to determine the effects of holding early-maturing cultivars, such as 'Hamlin' oranges, late into their seasons in order to obtain the highest total soluble solids for processing and other related problems, a practice which has become common in recent years.

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YIELD ESTIMATION OF 'VALENCIA' ORANGE RESEARCH PLOTS AND GROVES[1]

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Abstract. **Methods of estimating 1) tree size (canopy surface and vol), 2) bearing density (limb-unit counts, 2′ x 2′ frame counts, canopy photographic counts, and visible fruit counts), and 3) fruit size (wt and vol) were examined as parameters for estimating the yield per tree in 3 and 4 tree 'Valencia' research plots. Canopy vol combined with bearing density by frame or limb count and fruit vol (1974) or wt (1975) had R^2 values to yields from 0.24 to 0.85 for plots in 3 groves in 1974 and R^2 values from 0.48 to 0.57 for plots in 3 groves in 1975. None of the combinations of estimating variables predicted yields adequately. Increasing the number of frame counts per tree to more than the 2 used in this study and adjusting these values by canopy vol and fruit wt would probably reduce the estimating error to an acceptable level of ± 5% of actual yield. An estimating variable suitable for grove-size units had an 83% fit to yields in 1975 trials.**

Researchers have experienced extreme difficulty in recent years in getting consistent, accurate yield records from citrus research plots, especially in commercial groves. This has been due to the problems in coordinating with, and getting cooperation from, commercial picking crews. The expense of getting plots harvested has also in-

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creased substantially. Growers are also interested in yield estimation but on grove-size units. These estimations are helpful for projecting harvesting requirements and profits.

This work was undertaken to evaluate various potential tree and fruit measurements (estimating variables) in order to determine if a reliable yield estimating procedure could be developed for citrus research plots and individual grove blocks.

Materials and Methods

In 1974, data were collected on 32 plots (4 trees each) in a 12-year-old 'Valencia' grove near Haines City, and on 12 plots (3 trees each) in an old, nematode infested 'Valencia' block near Lake Alfred. All estimating data were collected shortly before harvest.

Tree canopy surface areas and vol were calculated by a computer program that determined the major axis of the tree and the tree's ellipsoid surface area and vol[3]. Tree measurements required included tree ht, canopy skirt ht, canopy max diam in horizontal plane, and vertical ht to max diam.

Canopy fruit bearing densities were measured in the following ways: 1) The fruit in a 61 x 61 cm (2′ x 2′) sq (frame counts (6)) projected to the center of the tree were counted on 2 sides of each tree at ½ the canopy ht (Fig. 1). 2) Two limb units per tree were selected that had diam between 18 and 20 mm (23/32 and 27/32 inches). The first limb unit to the right of each sq frame count meeting the size requirement was selected and its fruit counted (limb counts) (Fig. 1). 3) Counts were made of the visible fruit in color slides of each tree with the photos being taken from the center of the plot at a distance of 15 ft from the canopy surface. These counts were corrected for the amount of the total tree surface visible in the slide. 4) Visual counts of the fruit on 1/4 of each tree as seen from the center of the plot were made in the Haines City grove.

Fruit size was determined by measuring the circumference of the first 10 fruit per tree clockwise from the north side or by wt of a random 40 fruit sample per plot picked at approx 2 m (6′) ht.

In 1975, the same 32 plots in the Davenport grove were examined. An additional 6 plots were added to the Haines City grove and 15 plots (4 trees each) in a new grove near Polk City. The Lake Alfred grove was discontinued after 1974 because the trees were pushed out. Limitations on sampling procedures in 1975 included measuring fruit wt only on a random 40 fruit sample and measuring bearing densities in the canopy by limb and frame counts only.

Simple and stepwise multiple correlation and regression analyses were run on each year's data. Multiple stepwise regression and correlation to

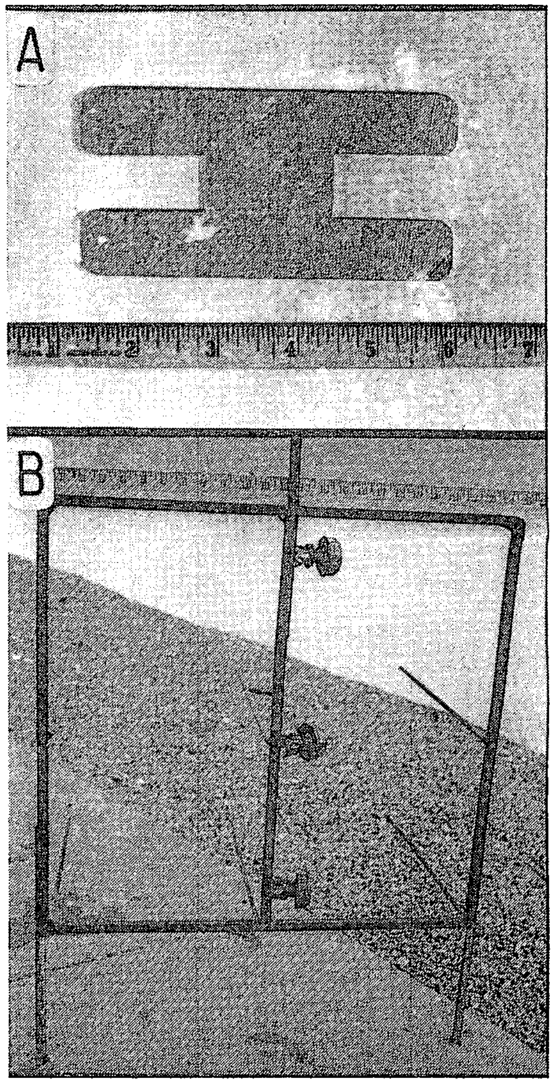

Fig. 1. A) Limb unit sizing gauge for selection of limb units with limb diam between the 18 and 20 mm slot widths. The selected limbs were used for fruit counts. B) Frame for fruit counts in 61 x 61 cm (2′ x 2′) area from canopy surface to center of the tree.

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[3]Based on procedures by C. A. Anderson, L. G. Albrigo, and J. D. Whitney, unpublished.

yield was run for selected 3 variable equations composed of a tree size, a bearing density, and a fruit size variable. Values obtained from fruit density ratios (1975/1974) x fruit wt ratios (1975/1974) x 1974 yields were tested for correlation to 1975 yields. Simple correlation coefficients (r) of +1 or −1 indicate a strong positive or negative linear relationship between the values of yield and the estimating variable. Values near 0 indicate little linear relationship exists between the values.

Correlation coefficients used for multiple regression (more than one estimating variable in the equation) are designated as R and range from 0 for no relationship to yield to values of 1 for complete explanation of changes in yield by changes in the estimating variables. The per cent of explanation or fit for the equation is given by r^2, R^2,, or the index of determination for nonlinear and linear equations. The standard error of estimate is the weighted average difference between actual and predicted yields.

Results and Discussion

Simple correlations. Many of the estimating variables were significantly correlated to average tree yields per plot. Details will be published in a future paper. Over the 2-year period, vol had the better overall correlation (r) to yield (ranging from 0.30 and 0.88) with canopy surface correlations ranging from −0.02 to 0.86. The weakness of canopy surface measurements occurs in hedge rows and large trees. The Polk City grove ($r = 0.28$) was in hedge rows so that no surface area was present between the trees in the row. This reduced the overall surface area even though the canopy vol were fairly large. The very large Haines City grove trees displayed very little relationship between yields and canopy surface in 1975 ($r = -0.02$). Part of the problem in the Haines City grove in 1975 may have been the observed large increase in numbers of inside canopy fruit in 5 plots under the same grove treatments. This inside fruit production would not be expected to relate very closely to canopy surface area.

Of the various measurements of bearing density within the canopy, the frame counts were most consistently correlated to yields over 2 years ($r = 0.23$ and 0.78). The limb counts were fairly good in each grove in 1974 ($r = 0.60$ to 0.62). This was not the case in 1975, where the low and high yield groves showed little relation between limb counts and yields ($r = 0.27$) and −0.15, respectively). The slight negative relationship of the limb count to yield in the Haines City grove in 1975 suggests limb counts should not be used. The higher production of inside fruit may have contributed to the inverse relationship of limb counts to yields. Fewer outside fruit may have been produced because greater inside yields occurred.

Photo counts of bearing density in 1974 studies correlated to yield particularly in the smaller Davenport trees ($r = 0.80$) where a greater portion of the fruit would be expected to be outside and visible on the tree. Nearly half of the tree was visible in the photo. In larger trees in the Haines City and Lake Alfred groves, smaller tree portions could be photographed and more fruit was inside and not visible (r's = 0.31 and 0.49). Even so, the correlation over all the groves was 0.78 after the photo counts were adjusted by multiplying by the number of counted surface area units that the total canopy surface represented. The photo count process was time consuming and gave no better results than limb counts or frame counts.

The visual counts in the Haines City grove in 1974 were correlated to yield ($r = 0.79$), and it did not take very long to count 1/4 of a tree. These counts did not measure inside fruit and were therefore discontinued in 1975. This method might be satisfactory for estimating yields in grove units when the estimator has knowledge that inside fruit distribution is normal.

Since both tree size and canopy bearing density should be involved in the resulting total tree yield, frame counts were converted to fruit per ft^3 of canopy and multiplied by total canopy vol. These values (adj. frame counts) were better correlated to yields (Figs. 2,3) than frame counts alone (r's = 0.63 and 0.73). These data in 1975 (Fig. 3) had an even better fit to a power function (yield = 0.63 and 0.73). These data in 1975 (Fig. 3) had an even better fit to a power function (yield = 0.01787 + adj. frame count 0.874) with an 83% fit as compared to 74% for the linear equation. The larger trees (Haines City grove) probably have more nonproductive lower and inside canopy. This canopy multiplied by the density of fruit found higher in the tree resulted in larger adjusted frame counts for the amount of fruit actually produced. This may be a special case where inside fruit production was exceptionally heavy (Fig. 2 vs. 3).

The other factor besides tree size and fruiting density that should establish a tree's total

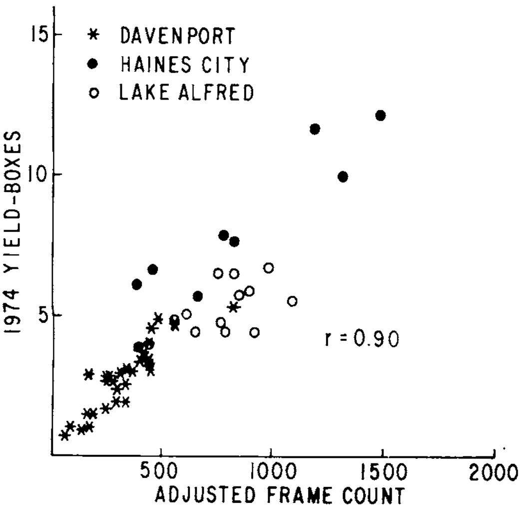

Fig. 2. Average tree yield per plot vs. adjusted frame counts (fruiting density in 2′ x 2′ frame x canopy vol) in 1974.

yield is fruit size. The estimate of fruit size by 40 fruit circumference measurements per plot calculated into fruit vol were poorly related to yield except in the Haines City grove (r = −0.51). Fruit wt of 40 fruit samples taken in 1975 were not significantly correlated to yield but a strong negative correlation of fruit wt to yield occurred for all groves combined in 1975 (r = −0.77). Larger tree canopy vol and increased fruiting density (mature groves) were negatively correlated to fruit wt (r's = —0.71 and —0.65, respectively) while yield was positively correlated to these 2 variables. The range of tree sizes and bearing densities (total yields) was not great enough in the mature trees to show this relationship except in the Haines City grove in 1974 (r = —0.51,

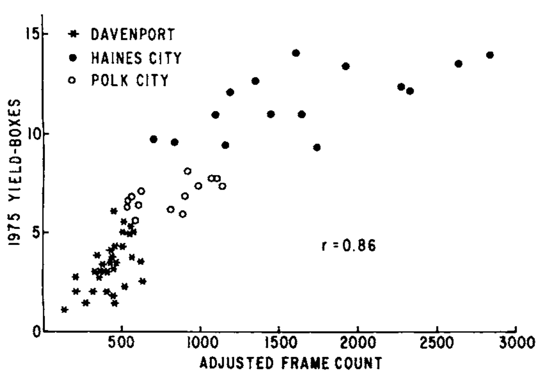

Fig. 3. Average tree yield per plot vs. adjusted frame counts (fruiting density in 2′ x 2′ frame x canopy vol) in 1975.

fruit vol) where plot yields varied from 3.9 to 12.2 boxes per tree.

Multiple correlation coefficients. When yields for plots in all groves were correlated to adjusted frame counts + fruit wt in 1975, the multiple R was 0.92 as compared to r's of 0.86 and —0.77, respectively, for the individual estimating variables.

Regression equations using canopy vol, limb counts or frame counts, and fruit vol or wt had from 24 to 85% fit to yields in the individual groves and 56 to 91% fit to yields over all the groves combined (Table 1). The boxes per tree standard errors of estimate were from 0.5 boxes for the Davenport grove in 1974 to 1.7 boxes per tree for the Haines City grove in 1975. These values are not good enough to predict research plot yields. Much of the error may have been the result of sample sizes.

Discussion and Conclusions

It would seem better to use only frame counts for bearing densities to avoid errors due to outside to inside fruiting differences. The importance of the amount of inside to outside fruit in sampling has previously been examined (3,5,6).

If greater reliability could be obtained by a slight increase in sampling and adjusting sampling techniques, the tree vol, frame count, and fruit wt equation might be successful. A logical step would be to double the counts per tree. Fruit production is known to be heavier on the east or southeast tree side (1,2,4). Counts in all 4 quadrants of the tree would reduce errors from favoring a given part of the tree in one grove as compared to another. This can easily happen with 2 counts per tree in hedge row trees and/or if rows run N-S in one grove and E-W in another. In a 10 plot experiment[4] using 8 frame counts per tree, an 88% fit was obtained between total fruit and frame counts. This is much better than the 5 to 61% range of fit of yields to frame counts obtained with only 2 counts per tree. The fruit size sample could be increased to 80 fruit per plot (3), and yields if recorded in pounds would be more precise than boxes of fruit. These changes might result in predictions with only 5 to 10% error, an acceptable level to detect yield differences of about 1 box per tree in mature trees.

This method of yield estimation using tree vol calculation plus fruiting density and fruit size sampling would be too complicated to use for estimation of a grove block. A simplification might be adapted. Since canopy size of large trees

Table 1. Multiple correlation coefficients squared (R^2) of yield vs. selected estimating variables.

Estimating variables[z]	All groves	Davenport	Haines City	Lake Alfred	Polk City
1974					
Can Vol-LCt-Frt Vol	0.56**[y]	0.81**	0.59*	0.44	--
Can Vol-FrCt-Frt Vol	0.65**	0.85**	0.76**	0.24	--
1975					
Can Vol-LCt-Frt Wt	0.91**	0.57**	0.50*	--	0.49*
Can Vol-FrCt-Frt Wt	0.91**	0.48**	0.51*	--	0.48*

[z]Variable names are: canopy vol (Can Vol), limb count (LCt), frame count (FrCt), fruit vol (Frt Vol), fruit wt (Frt Wt).

[y]R^2 significant at the 5% (*) or 1% (**) level.

normally will not change greatly from year to year, it could be ignored. Then, fruit yields would be expected to differ from the previous year by the change in fruiting density within the canopy and the change in average fruit wt from year t to year t + 1. The equation would be as follows:

$$\text{Yield } t+1 = b\left(\text{Yield } t\right)\left(\frac{t+1 \text{ Bearing Density}}{t \quad \text{Bearing Density}}\right)\left(\frac{t+1 \text{ Fruit Wt}}{t \quad \text{Fruit Wt}}\right)$$

The equation intercept should be 0 since no fruiting or no fruit wt in year t + 1 leads to no yield. Examination of data from all plots measured in both 1974 and 1975 shows that the data points approach 0 yield as the variables approach 0 (Fig. 4). Two data points had unusual fruiting density counts either in 1974 or 1975 (Fig. 4, circled). When these data were excluded, the equation for the line had an intercept not significantly different from 0, a standard error of estimate of 55.4 kg (122 lb.) per tree, and a r value of 0.91 (83% fit).

Using this formula, the average yields per tree for the combined 3 common plots per treatment in the Haines City grove were estimated and compared to the actual average. Actual and estimated yields were, respectively, 471.3 and 509.5 kg (1038.5 and 1112.2 lb.), 527.0 and 519.3 kg (1160.8 and 1143.8 lb.), and 408.1 and 318.6 kg (899.0 and 701.8 lb.) for the 3 treatments.

Any of the density measurements could be used if enough samples were taken and the same trees used each year. Perhaps 5 representative trees per acre would be enough. Fruit samples of 40 to 80 fruit per 5 trees should also be taken in the same way each year.

Counts and fruit wt could be taken in early fall also, but the results may not be as con-

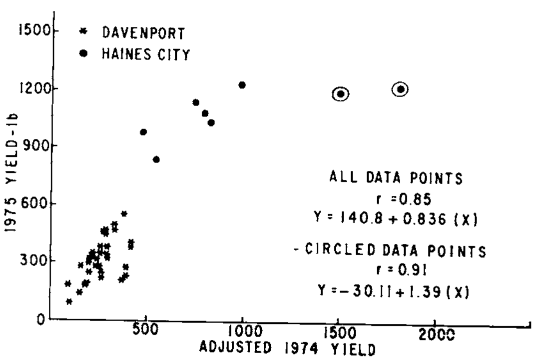

Fig. 4. Yields in 1975 vs. adjusted 1974 yields. Adjustment was made by multiplying 1974 yield by ratio of 1975/1974 frame fruit counts and by 1975/1974 fruit wt ratio.

[4]Unpublished work of L. G. Albrigo and H. R. Sumner.

sistent if larger fruit of one year and smaller fruit of another year do not increase proportionately in size from then to harvest. The method will be unsuccessful in groves after hedging or topping at least for the next year unless the reduced tree vol is taken into account and the bearing density measurements are taken proportionately in the area of reduced yields as well as in unaffected areas of the trees.

Some increase in yield should be expected each year in young groves due to increased tree size. Tree vol in the Davenport grove of 12-year-old 'Valencias' increased an average of 531 ft^3 (49%) from 1974 to 1975 while in the mature Gapway grove tree vol increased 278 ft^3 (7%). If tree size were constant and fruiting densities are used, equal fruiting densities and fruit size in the 2 years should result in equal yields. This means the slope coefficient should be 1. The coefficient of 1.4 in this study (Fig. 4) was apparently a reflection of increased yields from increased canopy size. Using fruit counts from the outside to the center of the tree instead of bearing density will compensate for increased tree canopy vol as the radius of the counted zone will also increase. With this method, the slope would be nearer to 1. It appears that a slope for the equation would have to be established for a grove to compensate for the increased yield due to canopy vol increase.

The use of adjusted frame counts (bearing density x canopy vol) along with average fruit wt showed some promise for predicting tree yields of research plots. Increased sampling is required to make this method practical. An advantage of this system would be that a yield increase response from a treatment would be easier to evaluate. The method would allow the researcher to partition the increased yield between responses to larger tree size, greater bearing density (fruit set), and increased fruit size.

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PLANNING OF SPRAY PROGRAMS FOR THE CONTROL OF FUNGAL DISEASES IN CITRUS GROVES

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Abstract. **Factors to consider in the planning of spray programs for the integrated control of scab, melanose, and greasy spot include: the disease history of a grove, variety, age of trees, and seasonal growth flush and bloom patterns. Whether a grove is to produce fruit for the fresh market or solely for processing has to be decided in advance, because this determines the number and type of spray applications required. Salient features of pathogen behavior and disease epidemiology are given to provide clarification of spray timing requirements. Also presented are spray programs considered necessary for different grove and disease situations.**

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The economic importance in Florida citrus groves of the major fungal diseases: scab (*Elsinoe fawcetti* Bitanc. and Jenk.), melanose (*Diaporthe citri* Wolf) and greasy spot (*Mycosphaerella citri* Whiteside) can vary considerably from year to year and from 1 grove to another. Such differences can usually be related to seasonal or local environmental conditions and to differences in inoculum pressure.

Experience has shown that all 3 fungal diseases can be effectively controlled by currently recommended methods provided these are correctly applied. Disease control failures can usually be attributed to faulty spray timing, poor choice of spray material, inadequate spray coverage, or to combinations of such defects. Another common