Performance Of An Auger Picking Head For Harvesting Fresh Market Oranges

. . . BY . . .
Harold R. Sumner
AND
Scott L. Hedden
United States Department of Agriculture
University of Florida, IFAS
Citrus Experiment Station
P. O. Box 1088
Lake Alfred, Florida 33850

Abstract

An experimental prototype auger picking head was field tested to determine its feasibility as a harvest method for fresh market oranges. Picking time, entries per tree, catching efficiency, per cent removal, harvest rate, and fruit damage were determined in early, midseason, and 'Valencia' oranges. Fruit removal ranged from 60 to 85% depending on fruit location on the tree. Picking time varied from 7 to 13 minutes per tree and was dependent on tree surface area.

Introduction

Florida harvested an average of 88 million boxes of oranges annually (2) during the past 10 years. Inertia shakers, air harvesters, and other mass removal equipment show promise for harvesting 40% of this fruit (early and midseason) for processing outlets. The remaining oranges, 15 million boxes for fresh market and 35 million boxes of 'Valencia' oranges (which has the young fruit for next year's crop on the tree at harvest time), must be handpicked. Research on an auger picking head has been aimed toward a harvest system for 'Valencia' oranges and for harvesting fruit destined for fresh market.

Coppock (1) began an investigation of the auger concept in 1960, and further developments were made by Lenker (3) during 1963-68. Lenker tested augers of different diameters and shapes to obtain an optimum auger design, then determined the best auger spacing and arrangement using a 16-auger picking bank. Finally, a 5' x 5' prototype auger bank having 80 augers was constructed for field testing. His preliminary tests indicated that the auger bank could harvest mature fruit with little damage or excessive removal of young fruit on 'Valencia' trees.

The objective of this study was to further test the 80-auger bank picking head to obtain information on its performance in harvesting oranges for "fresh fruit."

This harvest concept has not been fully developed, therefore, the number of replications in these tests were limited. However, the accuracy was considered sufficient for drawing conclusions on the potential of the harvest concept.

Equipment and Methods

The 80-auger picking head and truck-mounted positioner designed and constructed by Lenker (3) during 1967-68 were used for this study (Figures 1 and 2).

The positioner had a vertical travel of 21 feet and could extend outward to a maximum length of 16 feet and collapse to less than 2 feet for transport. It rotates through an angle of 30 to 150° with the direction of travel enabling the auger bank to be extended into the tree approximately perpendicular to the tree surface.

The 5' x 5' picking head has 80 augers

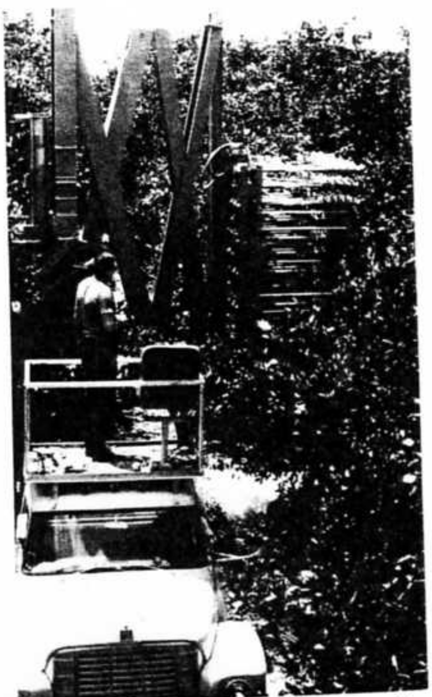

Figure 2. Auger bank entering tree with positioner raised and extending.

Figure 1. Positioner lowered and ready for entry into tree.

Cooperative research by the University of Florida, IFAS, Citrus Experiment Station; State of Florida, Department of Citrus; and U. S. Department of Agriculture.

Presented at the 82nd Annual Meeting of the Florida State Horticultural Society, Miami Beach, Florida, Nov. 4-7, 1969.

spaced 7¼ inches center to center in a triangular arrangement. The double-flight augers have a pitch of 2¾ inches with a major flight diameter of 5½ inches and a minor flight diameter of 3¼ inches. The augers are molded of neoprene on one-inch diameter aluminum shafts and have an effective picking length of 15 inches with a 40-inch tree penetration.

Initially, the augers were molded of pure gum rubber (40 durometer hardness) which tore rather easily. Replacement augers were made of neoprene (45 to 60 durometer). Four different neoprene formulations were tested to increase auger tear strength and improve performance.

Six 'Hamlin,' 5 'Pineapple,' and 26 'Valencia' orange trees were auger harvested to determine fruit removal and picking time. Tree size and shape were measured and surface area determined. Trees that appeared to be desirable for auger harvest were chosen. Those with large limbs near the canopy surface (as a result of hedging) and those with abnormal growth patterns were avoided. Picking time included time to position the augers (truck stationary) and to enter and withdraw from the tree. Time required to move the truck and empty the holding bag was excluded. The trees were picked from 2 sides with 3 picking positions per side at 45, 90, and 135° from forward travel of the truck. The augers were rotated at approximately 275 rpm in a counterclockwise direction (looking at the front of the auger bank) as the picking head was extended and retracted approximately perpendicular to the tree surface. The number of machine movements (enter, lower, raise, and rotate) per tree, fruit caught in the bag, fruit dropped on the ground, fruit left on the tree, and total yield were recorded. Fruit from the ground up to 4½ feet were handpicked since the picking head could not be lowered below

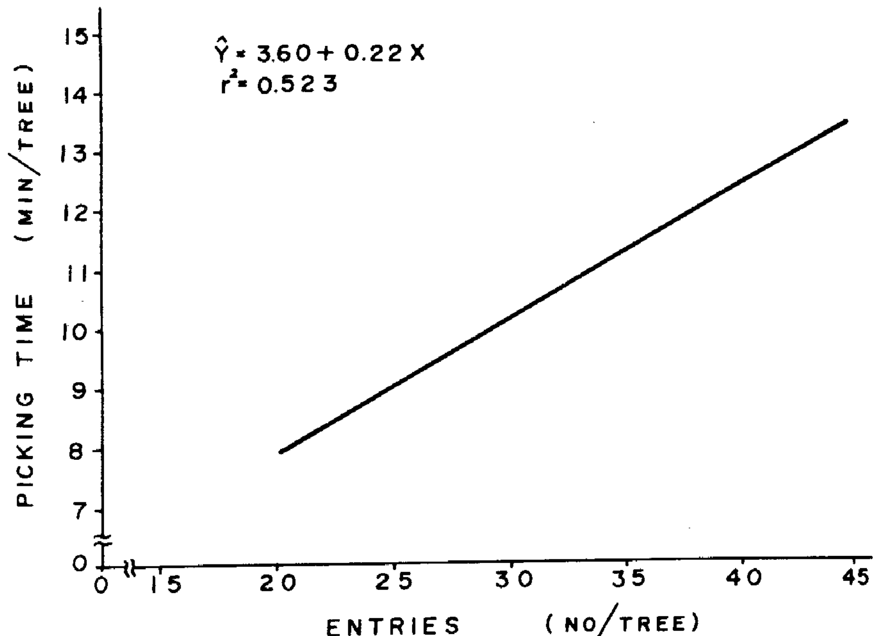

Figure 3. Relation of picking time to number of entries per tree.

Table 1.--Results of auger test showing the averages for each variety.

Variety	'Hamlin'	'Pineapple'	'Valencia'	'Valencia'	'Valencia'	'Valencia' (all)	All varieties
No. of trees	6	5	14	9	3	26	47
Hedged	Light	Light	Yes	No	No	--	--
Tree spacing (ft)	18 x 22	18 x 22	18 x 22	15 x 30	30 x 30	--	--
Surface area (ft^2/tree)	830	602	840	450	--	686	706
Total yield (boxes/tree)	6.37	5.90	3.98	5.65	3.31	4.42	4.95
Apparent fruit density (boxes/100 ft^2)	0.772	0.940	0.483	1.260	--	0.790	0.802
Entries (no./tree)	35.8	32.0	30.8	26.6	40.0	30.8	31.7
Machine movements (no./tree)	85.0	75.7	83.2	66.6	95.5	75.8	77.2
Picking time (min/tree)	12.7	10.0	10.8	8.9	11.0	10.2	10.6
Percent removal	66.6	89.8	66.7	79.8	77.2	72.7	75.6
Catching efficiency $\left(\frac{B}{P} \times 100\right)$	71.0	75.0	64.5	63.6	66.3	64.4	66.8
Picking rate (boxes/hour)	20.0	32.2	14.7	33.0	17.3	19.8	21.6
Machine:man ratio*	2.9	4.6	2.1	4.7	2.5	2.9	3.1

*Based on total fruit picked.

B = The number of fruit caught in the bag.

P = The total number of fruit picked.

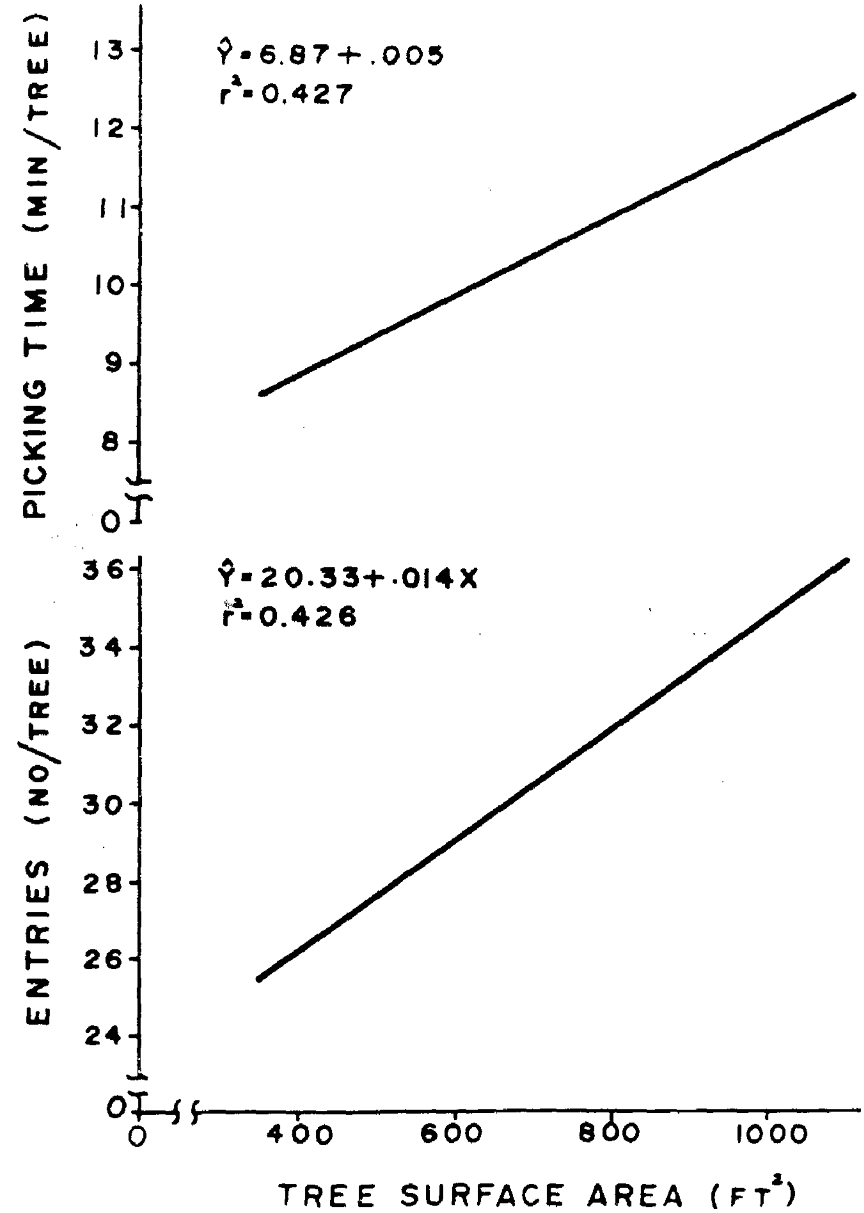

Figure 4. *Effect of tree surface area on the number of entries per tree and picking time.*

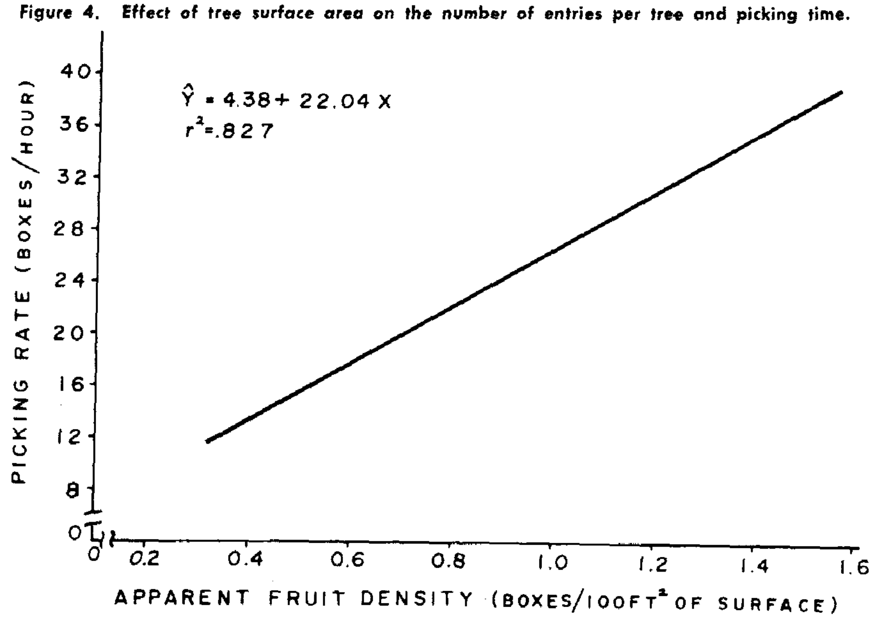

Figure 5. *Effect of apparent fruit density on auger picking rate.*

this height. Fruit samples were taken to determine the effect of auger harvest on fruit decay. 'Valencia' orange trees were picked at 3 dates approximately 2 weeks apart to determine the influence of date of harvest on harvest performance. Three trees similar in appearance (one check for fruit quality and 2 auger harvest) were grouped together for each of the 2 replications. Auger harvested and check trees were randomly selected.

Three 'Valencia' trees sprayed with an abscission chemical were picked and data compared with that from paired check trees.

Results and Discussion

The influence of tree size, shape, and distribution of fruit on the tree dominated the effect of fruit variety and date of harvest on picking performance. Table 1 gives average results by variety. Data from all fruit varieties were used to correlate the relationship in Figures 3, 4, and 5. The least squares method was used to correlate the linear relationship of the equations given in each figure. The percent variation caused by the independent variable is indicated by r^2. Picking time per tree (Figure 3) increased with the number of entries per tree as was expected. Trees with greater surface area (Figure 4) increased the entries required per tree and therefore increased picking time. High apparent fruit density resulted in higher picking rates (Figure 5) and points out the importance of high-yielding trees for auger harvest and other related harvest systems.

Most of the fruit that entered the auger bank was picked and conveyed to the picking bag. Fruit on limbs that were partly in the bank (fruit hanging out of the side of the bank) were lost to the ground. Trees with a high per cent of inside fruit and those with fruit concentrated in the top of the tree where the augers could not penetrate caused a low per cent removal. The highest average fruit removal (89.8%) was obtained in trees ('Pineapple' orange) with high yields and a large per cent of the fruit located on the outer canopy of the tree. This also resulted in higher picking rates and catching efficiency.

The average picking rate for all tests was 21.6 boxes/hour in trees yielding an average of 5 boxes. An average of 75.6% of the fruit was removed, and 66.8% of this fruit was caught in the holding bag. Trees had an average of 706 square feet of surface area and required 31.7 entries per tree and 10.6 minutes to pick. An average of 2.45 machine movements were required per entry into the tree. A machine to man

(Continued on Page 14)

PERFORMANCE OF AN AUGER PICKING HEAD FOR HARVESTING FRESH MARKET ORANGES

(Continued from Page 11)

ratio (machine picking rate to hand-picking rate) was obtained by assuming that one man would operate the auger picking head and that an adequate fruit handling system was available. A hand-picking rate of 7.0 boxes of fruit per hour was used (4). The machine to man ratio ranged from 2.1:1 in low-yielding trees to 4.6:1 in highly productive trees with a high per cent fruit removal.

Fruit from trees sprayed with chemical loosener had an average reduction in pull force from 24.1 to 16.7 pounds per fruit. The performance of the auger picking head in chemical-sprayed trees is given in Table 2. Per cent fruit removal of the abscission sprayed trees increased from 75.1 to 81.6% over the check trees; however, the catching efficiency was reduced from 66.3 to 59.4%. Leaf drop on the chemical-treated trees enabled the operator to see the fruit and more effectively place the picking head into the tree. The looser fruit tended to be shaken off the limbs before they were augered into the bank. The reduced picking time per tree (9.4 to 9.0 minutes) was a result of increased operator efficiency (since he could see the fruit) and the reduction in time required to remove the fruit from the chemical-treated limbs.

Tree damage by the auger head varied with grove conditions. Generally, the observed damage was low and probably acceptable in most groves; however, small branches were sometimes removed by the augers in trees (especially the 'Valencia' variety) that had a flush of new growth. The branches tended to clog the auger bank, and it was necessary to remove them after picking each tree.

Trees which had been hedged and had large stubby limbs presented harvest problems. The stubs tore the augers and caused the auger bank to be caught in the tree and in some cases auger shafts were bent.

Decay of fruit stored unwashed at 70° F for 2 weeks was used to indicate cate fruit damage while picking. Decay values for fruit handpicked, caught in the bag, and that which fell to the ground for 'Hamlin,' 'Pineapple,' and 'Valencia' oranges is given in Figure 6. Decay was greater for auger-picked fruit than for handpicked; however, it was acceptable for the fresh market. Note the increased decay of fruit that fell on the ground.

Summary and Conclusions

An auger picking head harvested an average of 21.6 boxes of oranges per hour with 75.6% fruit removal. An average of 89.8% fruit removal was achieved in high-yielding unhedged trees with a high percentage of fruit located on the outer canopy. Fruit dam-

(Continued on Page 22)

Table 2.--Effect of chemical on auger harvest performance.

'Valencia' oranges (Alcoma grove)	Abscission chemical*	Check
Picking time (min/tree)	9.0	9.4
Percent removal	81.6	75.1
Entries (no./tree)	32	34
Machine movements (no./tree)	77	80
Catching efficiency $\left(\frac{B}{P} \times 100\right)$	59.4	66.3
Total yield (boxes/tree)	3.34	3.29

*Pull force reduced from an average of 24.1 to 16.7 pounds per fruit.

B = Number of fruit caught in the bag.

P = Total number of fruit picked.

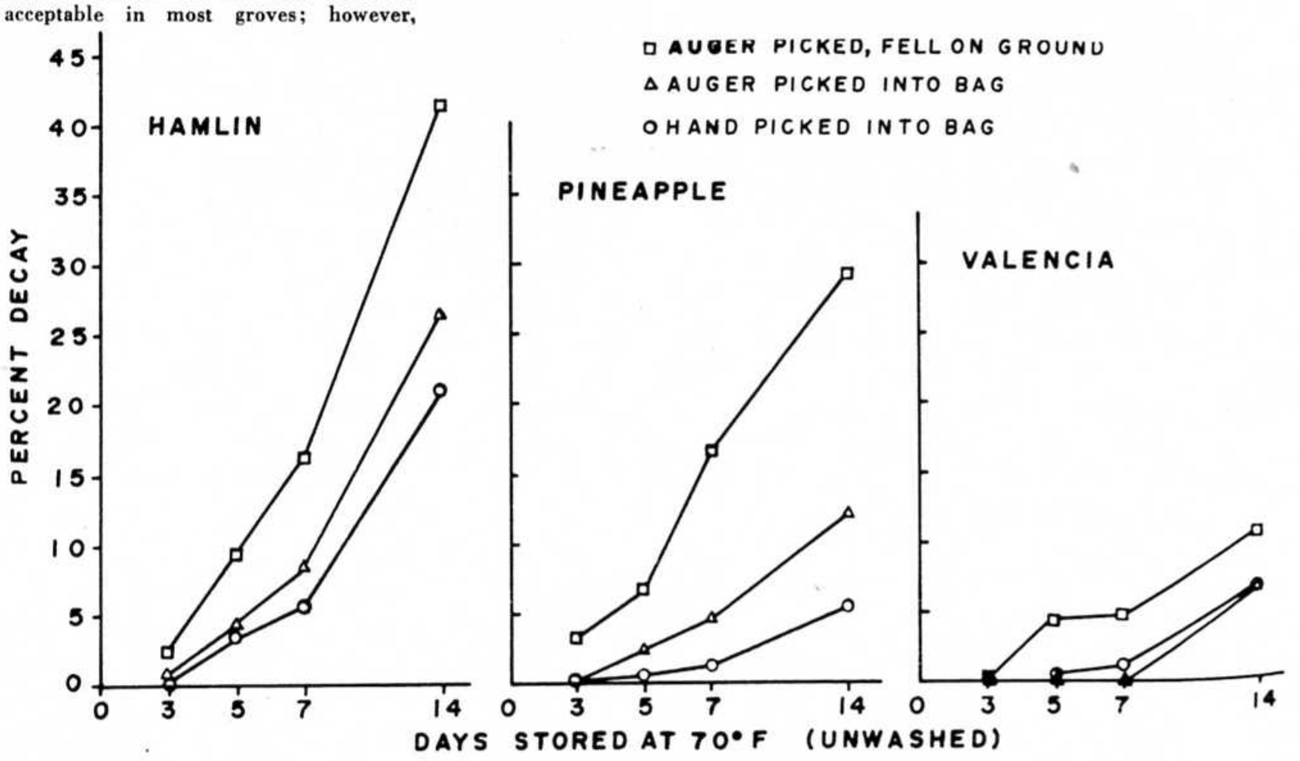

Figure 6. Decay of auger-harvested 'Hamlin,' 'Pineapple,' and 'Valencia' oranges.

PERFORMANCE OF AN AUGER PICKING HEAD FOR HARVESTING FRESH MARKET ORANGES

(Continued from Page 14)

age was almost as low as that for hand-picked fruit. The augers did little damage to the tree and picked most of the mature fruit that entered the bank while removing only a few of the young green fruit.

Relationships were developed which correlated the surface area of the tree with picking time and entries per tree, apparent fruit density with picking rate, and picking time with entries per tree.

In selected grove conditions, the auger-harvest concept shows promise for development into a fresh market orange harvester. Further machine development is needed to increase auger life and decrease picking time per tree.

LITERATURE CITED

1. Coppock, G. E. 1961. Picking citrus fruit by mechanical means. Proc. Fla. State Hort. Soc. 74: 247-249.

2. Florida Agricultural Statistics, Citrus Summary. 1967 Issue. Fla. Dept. Agr.

3. Lenker, D. H. June 1969. Development of an auger picking head for selectively harvesting fresh market oranges. Paper No. 69-123. Presented at the annual meeting of the Amer. Soc. Agr. Eng., Purdue Univ., W. Lafayette, Indiana.

4. Survey of Citrus Harvest in Florida 1967-68. Florida Industrial Commission in cooperation with Citrus Industrial Council Bureau of Employment Security, U. S. Department of Labor.

TARIFFS — HERE TODAY — GONE TOMORROW

(Continued from Page 5)

tariff problem is to liken it to asking your dog to get rid of his own fleas. If he scratches in one spot they just move somewhere else.

In all seriousness it seems that just when you have one department of government convinced, another department can spring a plan which could cause as much damage as the one you have just resolved.

I suppose this is why we can truthfully say that tariffs, while they may be here today, could well be gone tomorrow. On behalf of Florida Citrus Mutual's Board of Directors, and on behalf of Mutual's staff that works continuously under the policies set by this Board, I can assure you that the problem of maintaining tariffs has now become a daily project on behalf of every citrus grower in the state of Florida.

It is irritating and sometimes discouraging but it is our job. We accept it today as we have accepted it in the past and with the continued support and cooperation of each of you, and of each and every grower in the Florida citrus industry, we will do our utmost to see that tariffs are also here tomorrow.

CLASSIFIED ADS

83rd ANNUAL MEETING FLORIDA STATE HORTICULTURAL SOCIETY

(Continued from Page 19)

Plant Pathology Department, S. E. McFadden, Ornamental Horticulture Department, and L. C. Kuitert, Entomology and Nematology Department, IFAS, Gainesville.

3:30 - Influence of Growth Regulators on Plant Elongation and Rooting Response of Foliage Plants. R. T. Poole, Ridge Ornamental Horticultural Laboratory, IFAS, Apopka.

3:45 - Chemical Weed Control in Container Grown Woody Ornamentals. W. M. Morton, Plantation Field Laboratory, Ft. Lauderdale.

4:00 - Effects of Three Herbicides, Containers With and Without Bottoms and Soil Mixes on Growth of Four Woody Ornamentals. C. E. Whitcomb, S. Dean, and C. A. Conover, Ornamental Horticulture Department, IFAS, Gainesville.