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Impact of Mechanical Harvesting on the Demand for Labor in the Florida Citrus Industry

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IMPACT OF MECHANICAL HARVESTING ON THE DEMAND FOR LABOR IN THE FLORIDA CITRUS INDUSTRY

by

J. Kamal Dow

INTRODUCTION

Importance and Purpose of the Study

The Florida citrus crop is expected to grow from its present potential of about 190 million boxes per year to almost 300 million boxes per year a decade from now. If the present systems of manual harvesting were continued, the labor requirements of the industry by 1980 would be over 50 percent higher than they are now. Current trends indicate that the labor force available for agriculture will not be able to satisfy those requirements. Furthermore, the migrant labor force, a major factor in peak harvesting periods, is actually declining.

Because of the above, increasing emphasis has been placed on the development of mechanical systems for harvesting citrus. The results obtained so far indicate that mechanical harvesting of citrus for processing, as distinguished from fruit for table use, may become economically feasible in the near future. The adoption of the new mechanical systems will bring substantial changes in the labor market. Advance knowledge of these changes will help in preventing the hardships that might otherwise develop as a result of the mechanization process. It is

the main purpose of this study to explore the impact that the adoption of mechanical citrus harvesting systems will have on the demand for labor of different skill levels as well as the implications of that impact.

Summary of Results

Comparison of the different mechanical systems with the manual indicated that should the present trends in wage rates, production and citrus prices continue, it will be economically advantageous to use mechanical harvesting systems by 1975 or before. Due to the cautious attitude of growers toward adopting new methods and to the fact that not too much difficulty has been experienced so far in recruiting workers, it is anticipated that the mechanization process will be slow over the next five years and only 10 percent of the industry will be mechanized by the 1975-76 season. Mechanization should proceed at a faster pace after 1975. It is anticipated that by 1980 the degree of harvesting mechanization will range from 20 to 30 percent of the grapefruit to 50 to 60 percent of the early and midseason oranges.

One of the effects of mechanization will be to reduce the number of workers needed to harvest a certain size crop. Projected increases in production and the low level of mechanization anticipated indicate that the total harvesting labor requirements will continue to increase until 1975. Under the assumptions of the study, an average of about 25,000 workers will be needed that season during the peak months of January and February as compared with about 23,000 during the 1969-70 season. Only during one peak week of the 1969-70 season were 25,000 workers required. The impact of mechanization will be felt by the labor market beginning

in 1975. In spite of the much higher expected level of production, fewer workers will be required to harvest the 1980-81 crop than either the 1969-70 or the 1975-76 crops.

The most important impact of mechanization, however, will be on the skill structure of the labor force. It is expected that between now and 1980 the demand for less skilled workers will be reduced by about 15 percent during the peak months while that for skilled and semi-skilled workers will almost double. Although the demand for harvesting labor will remain highly seasonal, it seems that enough opportunities will exist for the employment of the skilled labor during the off-season. Such is not the case for the less skilled workers and efforts will have to be increased to find job opportunities for them whether it be in the industry, in other agricultural industries, or in non-agricultural activities.

It is expected that the results of this study will assist:

1. Federal, state and local governments. Officials concerned with manpower problems, adjustment of human resources, job placement and labor policy making in general will benefit from knowing the changes that will take place in the labor market. Such knowledge will assist them in planning programs aimed at improving the welfare of the labor sector of the economy. Training programs for the unskilled can be better structured if there is knowledge about the demand for the different skills in the industry. This will aid in reducing unemployment and underemployment by adjusting the future labor supply to the future needs.

2. Management. The results as well as the methodology developed in the study can be useful in making decisions concerning the combination of hand and mechanical harvesting to fit different conditions in the labor market. In addition, planning future employment policies will be made easier when those conditions are known. The availability of more stable employment for some of the workers will result in changes in the traditional employer-employee relationship that exists between pickers and management. Employers will have to recognize that permanent more-skilled workers will demand higher wages, better working conditions, and fringe benefits. The possibility of workers joining new or existing unions should not be discounted by management.

Implications

Technological changes that substitute capital for labor always have an impact on the labor market and unless preventive measures are taken they usually affect adversely some of the workers involved. The magnitude of the impact depends on how considerable the change in the capital-labor ratio is. For a given change, however, it is the characteristics of the workers affected along with the general market conditions which will ultimately determine the adjustments that will take place in the level of employment.

Mechanization will affect more adversely those workers whose mobility is lower. Major determinants of labor mobility are age, education, race, migratory status and work experience in other fields. These factors affect the ability of workers to adjust to changes in the demand for their services.

Younger workers should be less affected by mechanization since it is easier to train them in the new skills demanded by the adoption of mechanical systems. Similarly, it is also easier to train them for activities other than those in the citrus industry. Over 60 percent of the citrus pickers surveyed during the 1967-68 season were 44 years or younger, while over 40 percent were 34 years or younger. Thus, it appears that age would be a favorable factor in the implementation of manpower training programs for citrus pickers.

A worker's occupational mobility is greater the higher his level of education. Nearly 50 percent of the citrus pickers surveyed had less than a fifth grade education. Although this indicates a low educational level for pickers in general, the younger groups were better educated. Education, coupled with age, will probably result in one group of younger, better educated, workers which will be able to adjust to the new skill requirements and another group of the older less educated which will fill positions for which few or no skills are required.

Since some degree of discrimination exists in non-agricultural employment, inter-industry mobility is limited among black and other minority groups in the farm labor force. This fact is reflected in the figures on citrus picking experience. While almost 50 percent of the non-white males had 10 or more years experience, the figure for white males was slightly over 20 percent. There were no white women with more than 10 years of picking experience while for non-white women the figure was 29 percent. Educational levels seem to be lower among non-whites, which tends to add to the problem. The age distribution of the non-white pickers was not significantly different from that of the white pickers.

The composition of the citrus picking labor force as it relates to the migratory status of the workers varies throughout the season. The tendency is toward an increase in the percentage of interstate migrants as the season progresses toward its peak and the need for pickers increa A reduction in the total number of workers required throughout the seaso and a smoothing of the peak periods will therefore affect interstate migrant workers first.

Mechanization will reduce, but will not eliminate, the need for migration in order to find supplementary work during the off-season. Because of their unstable residential situation, migratory workers might not be able to take advantage of the same type of programs that would benefit local non-migratory workers. This fact, as well as the differen in characteristics that exist among workers, should be taken into accoun when implementing training and other types of programs.

The results of the study are encouraging in the sense that the cour that mechanization is expected to take seems to provide enough time for implementing programs designed to ease the hardships usually associated with transitions of the type dealt with in this study. Based on those results it appears that efforts should be concentrated first on estab- lishing training programs aimed at increasing skill levels to match thos required by the industry in the future, and secondly, on finding off- season employment for those workers whose characteristics prevent them from acquiring new skills and enjoying year-round employment in the citr industry.

CHAPTER I

THE CITRUS INDUSTRY AS AN EMPLOYER OF AGRICULTURAL LABOR

Employment Patterns

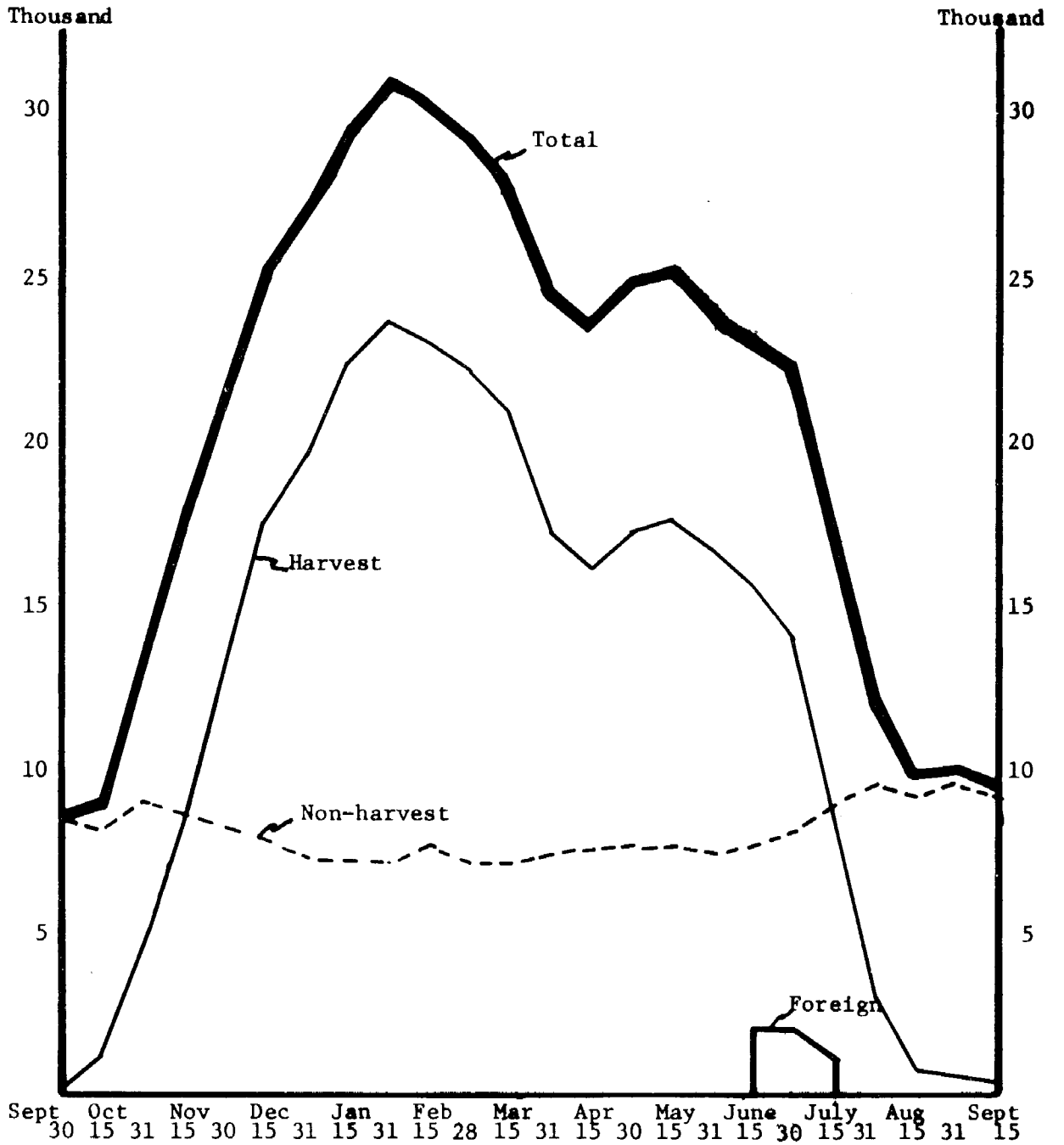
The citrus industry employs more farm labor than any other agricultural activity in the state of Florida. During the peak employment period of the 1967-68 season, 30,673 or almost 40 percent of the 78,037 seasonal workers employed in Florida agriculture were employed by the citrus industry.

Like most activities in specialized commercial agriculture the need for labor in the citrus industry is highly seasonal. Figure 1 shows employment in citrus during the 1968-69 season. Total employment varied from 8,614 during the late part of September 1968 to 30,918 workers in late January 1969. The number of workers used in harvesting ranged from a low of 147 to a high of 23,823. The peak and low periods in harvesting employment coincide with those of total employment.

The patterns illustrated in that figure are typical of Florida citrus activities; there is a period of about 90 days, usually centered in late August, where the need for harvesting labor is practically non-existent. Starting in late October employment rises continuously and reaches a peak usually in late January. It then starts falling until late March or early April when the harvesting of most early and midseason varieties has been completed. It is during this lull between the early and mid-season and the late harvest when a critical period occurs; many unemployed or underemployed workers leave the state thus making it harder for

FIGURE 1

FLORIDA - AGRICULTURAL EMPLOYMENT IN THE CITRUS INDUSTRY
1968-69 SEASON



SOURCE: Farm Labor Statistics Department, Florida Industrial Commission, Tallahassee, Florida.

employers to recruit pickers for the Valencia harvest. During the high crop seasons of 1966-67 and 1968-69 it was necessary to bring in foreign workers in June and July. The peak of the Valencia season usually occurs during the month of May and after that employment drops steadily until the end of the season.

Harvesting activities take up a large share of the citrus labor force. The remainder is absorbed in production and maintenance activities such as grove care, spraying and fertilizing. As can be observed in Figure 1 non-harvest employment does not present seasonal characteristics to the same extent as harvest employment. The number of workers engaged in non-harvest activities varied from a low of 7,029 to a high of 9,446. The peak occurs during the post-harvest period while the period of lowest employment is during the winter months when harvesting labor requirements are high. This permits movement of workers from one activity to the other although, as the figures suggest, the amount is rather small when compared with total labor requirements.

General Characteristics of the Citrus Harvesting Labor Force

Comprehensive statistics concerning the main characteristics of the labor force employed in harvesting citrus are not available. The Florida Industrial Commission in cooperation with the Bureau of Employment Security, U. S. Department of Labor has undertaken the job of surveying some of those characteristics. Two surveys of citrus harvest labor have been made available so far; a sample of 55 crews covering a total of 512 workers are used in the 1967-68 Survey. Some of the results of this survey are summarized below.

Race, sex and migratory status. Eighty five percent of the citrus pickers in the Survey were non-white and 90.8 percent were males. The ratio of men to women was the same for whites and non-whites, about 9 to 1. The bulk of the picking labor force was composed of non-white males which accounted for 77.5 percent of the total. Slightly over two thirds were non-migrating residents of Florida while 29 percent were interstate migrants; only 2.5 percent were intrastate migrants. Two thirds of the interstate migrants were non-white. The percentage of interstate workers increases as the season progresses, however, The 1966-67 Survey pointed out that the proportion of interstate workers had increased to 46 percent in March and reached 50 percent in May.

Age and educational background. Ages of the citrus pickers ranged from 14 to 72 but almost two thirds of the sample fell into the 25-54 age bracket. There were more workers (23 percent) in the 35-44 age group than in any other; 18.6 percent of the workers were 24 years of age or younger. Local workers were in general younger than interstate migrants. Almost two thirds of the interstate migrants surveyed were 35 years or older, compared with 45.4 percent of the local pickers. There was no significant difference in the age distribution of whites vs. non-whites.

Nearly one half of the pickers interviewed had a fifth grade education or less (10.9 percent had less than a third grade education and 37.7 percent were in the grades 3-5 bracket); 27.7 percent were in the grades 6-9 group; 23.1 percent in the grades 10-12; and 0.6 percent received more than a high school education. The younger groups, as would be expected, were generally better educated than the older ones. This was particularly noticeable in the 18 to 24 age bracket. In this group 86.1 percent of all men had better than a fifth grade education as compared

with 58.1 percent for the 25-34 bracket, and only 16.9 percent for the 55-64 group. Seventy five percent of the men in the 14-17 group had better than a fifth grade education. This group was affected, of course, by the fact that many of its members were still attending school and had not completed their education.

The level of education was higher among white workers. The percentages of workers with more than a fifth grade education were 66.2 for white males and 48.6 for non-white males. The difference was even wider for female workers. While 77.8 of the white females had more than a fifth grade education, only 47.4 of the non-white women had similar school training. There are no data available for comparison of educational levels of migrants vs. non-migrants.

Mobility and citrus experience. According to the Survey, 88.5 percent of the workers interviewed had worked for only one employer during the season. The Survey points out that this figure is high because most of the interviews took place near the beginning of the season. Turnover increases as the season progresses and the average turnover rate is much higher than the Survey indicates. This was illustrated in the previous survey (1966-67 when only 16 percent of the December sample had worked for more than one employer, but this percentage increased to over 50 percent for the May sample.

Over 80 percent of the pickers in the sample had two or more years experience and over 40 percent had 10 years or more. Experience was greater among non-whites and Florida residents than among whites and interstate migrants.

Average employment and earnings. Pickers worked an average of 6.1 hours per day 3.5 days per week for an average of 21.4 hours per week. The average number of weeks worked during the season was 5.1 per picker. Employment was higher on Tuesday and Wednesday and lower on Monday, Thursday and Friday. The Survey points out that the total man-weeks for the season was determined by a count of all workers who worked at all during any week. For example, a picker who joined a crew and worked for only one day was counted as a man-week. Since the average number of hours per week and days per week was computed by dividing total man-hours and total man-days, respectively, by total man-weeks the results tend to be biased downward.

Citrus pickers are paid on a piece rate basis. Prevailing rates during the 1967-68 season were 30 cents for oranges, 20 cents for grapefruit, 85 cents for tangerines and 45 cents for tangelos and murcotts. The distribution of average hourly earnings showed that 27.1 percent of th workers earned $2.50 per hour or more whereas only 2.1 percent received less than $1.15 per hour. The average hourly earnings for all types of fruit was $2.36 per hour. Average weekly earnings amounted to $50.60 but over 50 percent of the workers earned less than $30.00 per week. Low weekly earnings are a result of working only a few days per week, not of low hourly earnings. This seems to indicate that a large number of workers consider citrus employment as a means to achieve a certain target income rather than as a desirable full time occupation. Once their target income for the week is achieved they seem to lose their motivation for working. This hypothesis is supported further by the fact mentioned above that employment is higher on Tuesdays and Wednesdays and lower on Mondays, Thursdays and Fridays.

Skill Structure of the Harvesting Labor Force

The statistics published by the Florida Industrial Commission provide a breakdown of the harvesting labor force between pickers and non-pickers. The pickers can be assumed to be relatively less skilled workers. Non-pickers include mainly tractor drivers, goat truck operators and crew leaders, that is, workers with a certain degree of mechanical or supervisory ability. They can be considered as being semi-skilled and skilled. The ratio of skilled and semi-skilled to relatively less skilled workers remains fairly stable throughout the harvesting period as the figures in Table 1 show for 1968-69. A least squares line was fitted to the data available. After eliminating the slack period (July 31 to October 15) there were 64 observations remaining between October 31, 1966 and May 31, 1969. The following equation was obtained:

$$Y = 185.90 + 0.13\ X \qquad (R^2 = .82)\ (I\text{-}a)$$

where Y is the number of non-pickers and X is the number of pickers. In seven of the nine harvesting months the X ranged from around 12,000 to around 20,000 which gives ratios of 6.9:1 and 7.2:1 pickers to non-pickers, respectively. It can be said that on the average the present manual harvesting system takes one skilled or semi-skilled worker for each seven less skilled workers.

Productivity and Labor Requirements

The Florida Industrial Commission Survey estimated the average productivity of pickers for different fruit varieties. Production rates in boxes per picker hour were 7.4 and 6.8 for early and midseason oranges for 1966-67 and 1967-68, respectively, 7.3 and 7.2 for valencias and 11.0 and 10.9 for grapefruit. Production rates can be used to calculate the number of man-hours needed to harvest a given amount of fruit. It is

TABLE 1

CITRUS HARVESTING. RATIO OF PICKERS TO NON-PICKERS
1968-69 SEASON

Period	Number of		Ratio
	Pickers	Non-pickers	
10-31-68	4,011	498	8.0:1
11-15-68	7,289	1,104	6.6:1
11-30-68	11,651	1,491	7.8:1
12-15-68	15,569	1,962	7.9:1
12-31-68	17,460	2,110	8.2:1
1-15-69	19,652	2,562	7.7:1
1-31-69	21,206	2,617	8.1:1
2-15-69	20,343	2,629	7.7:1
2-28-69	19,651	2,601	7.6:1
3-15-69	18,382	2,439	7.5:1
3-31-69	15,132	2,087	7.3:1
4-15-69	14,180	1,903	7.4:1
4-30-69	15,149	2,110	7.2:1
5-15-69	15,486	2,118	7.3:1
5-31-69	14,567	2,099	6.9:1
6-15-69	13,749	1,926	7.1:1
6-30-69	12,381	1,709	7.2:1
7-15-69	7,670	1,000	7.7:1
Average	-----	-----	7.5:1

SOURCE: Farm Labor Statistics Department, Florida Industrial Commission Tallahassee, Florida.

important, however, to know how many different workers are needed during a specified period of time to harvest that fruit. The relationship between man-hours and number of workers depends on the average number of hours worked per picker as well as on the turnover rate.

Based on employment figures published by the Florida Industrial Commission some equations for determining labor needs were developed by Leo Polopolus of the Economic Research Department, Florida Citrus Commission.[1/] Using linear regression techniques, he estimated the relationships between weekly boxes harvested and number of harvest workers. The following different relationships for the different sub-seasons were found:

$$Y = 444 + 4.634\ X \quad \text{(Early season)} \quad \text{(I-b)}$$

$$Y = 9{,}747 + 1.7222\ X \quad \text{(Midseason)} \quad \text{(I-c)}$$

$$Y = 3{,}383 + 2.698\ X \quad \text{(Late season)} \quad \text{(I-d)}$$

where X is weekly boxes harvested in thousand and Y is number of harvest workers on an average daily employment basis.

Applying these equations to the 1968-69 production data gives a peak harvesting employment of 23,261 workers. The actual figure was 23,823 or less than 2 percent different from the predicted value. Subject to some qualifications to be discussed later, the above equations can be used with confidence to determine harvesting labor requirements under the manual system.

[1/] Leo Polopolus, A Mathematical Determination of Weekly Harvest Labor Requirements for Florida Citrus. Economic Research Department, Florida Citrus Commission, University of Florida, August 1968, 36 pages. (Unpublished paper.)

CHAPTER II

PRODUCTION AND UTILIZATION OF FLORIDA CITRUS

The transition between the employment patterns discussed in Chapter I and those projected later in the study needs to be viewed in the light of certain characteristics of the citrus industry. Such characteristics as production and utilization will exert great influence in the changes that will take place in the demand for labor.

Production

Florida is the leading citrus-producing state in the nation. During the 1968-69 season it produced 60 percent of all the oranges, 77 percent of all the grapefruit and 83 percent of all the tangerines produced in the United States.

Florida oranges fall into three general categories depending on the time they reach maturity: Early varieties which are harvested during late October and November; midseason varieties which are harvested starting in December and lasting until the middle of March; and late varieties which are harvested from March until the early part of the summer. This distinction is important for this study not only because of the influence of maturity date on the seasonal labor requirements but also because the late varieties present more complex problems for mechanization. In grapefruit, the important distinction for mechanization purposes is between the seedy and the seedless varieties because of their different final utilization.

Table 2 shows the volume of production of the main Florida citrus from 1950-51 to present. If the latest and earliest five-year period averages are compared, an increase of over 40 percent in production can be observed for oranges. Both the early-midseason and the late groups have increased production although the former has done it at a slightly faster rate than the latter. The increase in orange acreage discussed above seems to indicate that the upward trend in production should continue in the future. Projections of future production will be discussed in more detail in a later chapter.

Production of grapefruit has remained at a relatively stable level over the last two decades, but the variety composition of that production has changed. There has been a substantial decrease in the production of seeded grapefruit that has been offset by an increase in production of the seedless varieties. Grapefruit production should show an increasing tendency in the near future due to the substantial increases in plantings that have taken place during the last five years.

Tangerine production has shown a slight downward trend during the last twenty years. Average annual production for the 1965-69 period was 4.0 million boxes compared with 4.8 for the 1951-55 period. This downward trend should be reversed in the near future due to the increased plantings of the last five years.

Utilization of Florida Citrus

Prior to World War II over 80 percent of the total Florida orange crop was shipped to the fresh market. Since then, larger volumes of production plus the creation of new types of canned and processed citrus

TABLE 2

FLORIDA PRODUCTION OF ORANGES, GRAPEFRUIT AND TANGERINES
1950-51 to 1968-69

Crop Season	Oranges			Grapefruit			Tangerines
	Early & Midseason	Late	Total	Seeded	Seedless	Total	
	-Million Boxes-						
1950-51	36,800	30,500	67,300	17,400	15,800	33,200	4,800
1951-52	43,800	34,800	78,600	18,300	17,700	36,000	4,500
1952-53	42,300	29,900	72,200	15,400	17,100	32,500	4,900
1953-54	50,200	41,000	91,200	20,100	21,900	42,000	5,000
1954-55	52,000	36,400	88,400	14,300	20,500	34,800	5,100
1955-56	51,500	39,500	91,000	17,700	20,600	38,300	4,700
1956-57	54,300	38,700	93,000	14,800	21,600	37,400	4,800
1957-58	52,700	29,800	82,500	13,500	17,600	31,100	2,100
1958-59	47,100	38,900	86,000	14,600	19,600	35,200	4,500
1959-60	49,000	42,500	91,500	10,400	20,100	30,500	2,800
1960-61	51,000	35,700	86,700	12,400	19,200	31,600	4,900
1961-62	56,900	56,500	113,400	11,200	23,800	35,000	4,000
1962-63	45,500	29,000	74,500	10,000	20,000	30,000	2,000
1963-64	27,800	30,500	58,300	6,600	19,700	26,300	3,600
1964-65	46,400	39,800	86,200	10,200	21,700	31,900	3,900
1965-66	51,500	48,900	100,400	11,200	23,700	34,900	3,600
1966-67	78,200	66,300	144,500	13,500	30,100	43,600	5,600
1967-68	55,900	49,100	105,000	9,200	23,700	30,900	3,800
1968-69*	74,200	61,000	135,200	12,200	28,000	40,200	4,300

*Preliminary

SOURCE: Florida Agricultural Statistics, Florida Department of Agriculture, Tallahassee, Florida.

products have contributed to increasing the percentage of the orange crop that is processed before being marketed. At the present time over 80 percent of the Florida orange production is utilized by processors. The figures in Table 3 clearly show the tendency to process a larger part of the orange crop. This trend should continue in view of the likely increase in future production and the failure of fresh orange consumption to keep up with it. The proportions of fruit marketed fresh and processed do not differ significantly between the early-midseason and the late varieties. During the last ten years, on the average, 78.4 percent of the total production of early and midseason oranges has been processed compared with 83.5 percent of the late varieties.

Grapefruit is not processed to the same extent that oranges are and there is no clear trend. Approximately the same numbers are being processed now as were during the late forties. Over 80 percent of the acreage planted over the last five years belongs to the seedless varieties. Only about 50 percent of seedless grapefruit goes to processors as compared with 90 percent of the seeded type. Thus, the increased number of seedless that goes to processors (due to increases in production) has offset the effect of the decrease in production of seeded varieties. Unless consumption of fresh grapefruit increases in the future larger numbers will have to be utilized by processors.

The number of tangerines used by processors has fluctuated widely from year to year. It was as low as 397,500 boxes in 1962-63 and as high as 1,587,000 boxes in the 1960-61 season. The number of boxes going to the fresh market has not varied as widely and, except for the years of low production, it has fluctuated between 3.5 and 4.5 million boxes per year.

TABLE 3

UTILIZATION OF FLORIDA CITRUS
1950-51 to 1967-68

Season	Percent of Crop Used by Processors		
	Oranges	Grapefruit	Tangerines
	- - - - - - - - - - - - - - Percent - - - - - - - - - - - - - -		
1950-51	61	53	20
1951-52	59	37	14
1952-53	62	45	22
1953-54	68	47	21
1954-55	68	44	21
1955-56	71	48	20
1956-57	73	51	26
1957-58	78	53	17
1958-59	80	50	35
1959-60	76	47	17
1960-61	80	51	32
1961-62	81	47	31
1962-63	84	53	20
1963-64	78	44	32
1964-65	80	50	27
1965-66	83	56	19
1966-67	86	60	19
1967-68	85	55	24

SOURCE: Florida Canners Association, Statistical Summary, Winter Haven, Florida, Published annually.

This seems to indicate a rather stable market for the fresh product. Unless demand for fresh tangerines increases in the future, larger amounts will have to be processed in order to take care of the projected increases in production.

CHAPTER III

MECHANICAL HARVESTING SYSTEMS BACKGROUND AND ECONOMIC COMPARISON

Background

Harvesting is the only stage in the Florida citrus industry in which mechanization has not kept pace with other crops. Machines are used for cultivating, fertilizing, spraying and tree shaping, not to mention the operations that take place after the fruit leaves the grove. The harvesting operation, however, is still done entirely by manual means.

Many attempts have been made to develop mechanical aids to help increase the productivity of the picker. Some of these are of a very simple nature such as clipping devices attached to the end of a long pole. Others like the man-positioning machines are of a more sophisticated nature. That type of aid has not been successful because its high capital cost can not be offset by the gains in productivity.

True mechanical harvesters can be classified as belonging to either of two classes: contact removal harvesters or mass removal harvesters. Contact removal harvesters have not been very successful because of their removal potential being limited to the outer 18 inches of the canopy thus leaving up to 40 percent of the fruit on the tree. Although they are not economically feasible at the present time, contact removal type harvesters seem to offer possibilities for use with the late oranges because of their dual crop characteristic. By making direct contact with the fruit, the ripe fruit can be removed while leaving the young fruit on the tree.

Mass removal systems do not present as many problems as contact systems and they seem to be at a more advanced stage of development. It is the general consensus that systems of this type will be the first ones to be used extensively in Florida citrus. The operation of these systems has been satisfactory in all citrus except for valencia oranges where some reduction in the following year's crop takes place due to the presence of the young fruit at the time of harvesting. It is expected that some abscission chemicals will be developed which will alleviate this problem in the future. Three mass removal systems were studied and compared with the manual system:

Air Blast System

This system uses an oscillating blast of high velocity air that shakes the tree limbs and removes the fruit which falls on an attached catching frame. A conveyor moves the fruit from the catching frame to a basket; once the basket is full it is unloaded into a goat truck which takes it to the roadside trailer.

One air blower, two tractors, two catching frames and the services of a highlift truck are required for the operation of this system. Personnel requirements are two tractor drivers, one blower operator, one driver for the highlift truck and two unskilled workers to pick up oranges that fall outside the frames or truck and keep the system clear of branches and any large foreign material. Future design improvements are expected to eliminate the blower operator and the non-skilled workers.

At its average speed of one-fourth of a mile per hour, and taking into account the time it takes for the machine to turn from one row to

the next, the rate of harvesting of this system is about 30 trees per hour.[1/] The rate of removal without the use of abscission chemicals is about 80 percent of the fruit on tree. Some pruning of the trees is necessary in order to operate the system smoothly; cost of shaping the trees was taken to be $0.24 per tree per year. Some fruit needs to have the stems detached and there is slight fruit damage; the cost of stem removal and fruit damage was assumed to be $0.04 per box. This system offers the best labor saving potential of all three. Under present conditions, and based on average yields for older trees, each worker employed with this system will do the work of 3.7 average manual pickers. With the improvements expected for 1980 each worker employed with an air blast system will replace 7.4 pickers. The labor replacement potential varies directly with yields. It can be calculated using the figures in Table 8, Chapter IV and the productivity rates of manual pickers given in Chapter II. For a successful operation this system requires very flat terrain for stability and long rows of trees in order to minimize the time spent turning from one row to the next.

Mechanical Shaker and Catching Frame

This system consists of two tractor-drawn catch frames each equipped with a limb shaker to remove the fruit from the trees. The catching frames automatically collect the harvested fruit and store it in a bin equipped to unload into a conventional lift body grove truck which delivers the fruit to a roadside trailer. Each truck can serve two

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[1/] Harvesting rates for all systems are based on an average distance between trees of 20.5 feet.