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A study was made to determine and examine the economics of the mechanical harvest of tomatoes in the Salinas Valley of California. To achieve this objective, it was necessary to detail the related cultural requirements of the machine harvested crop to the extent they differ from the hand picked crop. Cultural operations, procedures, and costs for the hand and machine harvest crops were kept within the framework of the conditions presently found in the area. The study was initiated by a contemplated labor shortage for hand picking which makes evaluating alternative methods of harvesting necessary.

Information for the study was collected from growers in the area, individuals in related service industries, and from published material, including a cost study on the machine harvesting of tomatoes in another area by the University of California, Davis. Using the data collected and the assembled information, the economics of mechanical tomato harvesting was examined by developing, using the

budget technique, two economic models; one for hand picking and one for machine harvest and making the necessary comparisons. The results found could not be compared with findings of other researchers since only fragmentary economic data pertaining to the complete cost structure of a mechanical tomato harvesting operation are available.

The special cultural requirements of the tomato crop to permit mechanical harvest were discussed as well as the harvest procedures and practices.

The two economic models were structured on the basis of standard cultural practices for hand harvesting and the practices projected and discussed for machine harvesting. Each model was developed for 75 acres of tomatoes as part of a 500 acre diversified farm. Growing conditions were assumed to be normal for both harvesting methods as were yields at 25 tons per acre. Costs in the models were structured on the basis of actual or projected inputs, rates, and prices.

Based on conditions, rates, and charges used in the economic models, it was found that the total of all costs for the hand harvest crop were $684 per acre compared to $615 per acre for the machine harvest crop. The harvest costs were found to be $326 per acre for hand harvesting and $246 per acre for machine harvesting. Costs other than harvest were not greatly different.

In order to determine the feasibility of a new method of harvest, the effect on revenue must be considered as well as the impact on costs. Gross revenue from the machine harvest operation was $713 per acre, which was eight dollars less per acre than for hand harvesting. However, because of the much lower costs of machine harvesting, the net revenue was $98 per acre for the machine harvest model compared to $38 per acre for the hand harvest model. The net advantage in favor of the machine harvest method amounts to $60 per acre.

From the information analysed, it was concluded that the capital required for mechanical harvesting equipment would be a limiting factor in many situations. Although acreage could be limiting in some cases, only about 38 acres of tomatoes would be required for justification of mechanical harvesting equipment.

It was concluded that the mechanical harvest of tomatoes in the Salinas Valley is currently economically feasible and its advantage over hand picking probably will increase with the passing of time.

THE ECONOMICS OF MECHANICAL HARVESTING OF TOMATOES IN THE SALINAS VALLEY, CALIFORNIA

by

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Typed by Marion F. Palmateer

To My Parents,

who have made this work possible.

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TABLE OF CONTENTS

Chapter		Page
I	INTRODUCTION	1
	Statement of the Problem	2
	Method of Study	3
	Literature	4
II	CULTURE AND HARVEST OF TOMATO VARIETIES ADAPTED TO MECHANICAL HARVEST	5
	Varieties	6
	Row Spacing and Field Size	8
	Seedbed Preparation	9
	Planting Dates	10
	Seeding and Thinning	11
	Weed Control	12
	Fertilizer	13
	Irrigation	14
	Cultivation	15
	Insect Control	17
	Nonparasitic Disorders	18
	Harvesting	20
	Preparation for Harvesting	20
	Operation	22
	Product Quality	24
III	DEVELOPMENT OF ECONOMIC MODELS	26
	Procedure	26
	Equipment Costs	27
	Labor Charges	28
	Preplanting Operations	30
	Seed Price	35
	Growing Costs	37
	Hand Harvest	37
	Machine Harvest	38
	Factors Affecting Harvest Costs	39

Chapter		Page
	Varieties and Yield	39
	Product Inspection	40
	Product Sales Contract	41
	Over-tolerance and Rejection of Fruit	42
	Harvest Costs	44
	Hand Picking	44
	Machine Harvest	44
IV	DISCUSSION OF ECONOMIC MODELS	47
	Preplanting Costs	47
	Hand Harvest Model	48
	Machine Harvest Model	49
	Growing Costs	50
	Hand Harvest Model	52
	Machine Harvest Model	53
	Harvest Costs	54
	Hand Harvest	54
	Machine Harvest	56
	Labor	56
	Harvesting Machine	59
	Summary of Costs	63
	Revenue	65
V	SUMMARY AND CONCLUSIONS	68
	Summary	68
	Conclusions	70
BIBLIOGRAPHY		73
APPENDICES		77

LIST OF TABLES

Table		Page
1	Projected Equipment Inventory and Use Costs on 75 Acres of Tomatoes as Part of a 500 Acre Farm, Salinas Valley, California.	29
2	Budgeted Operations and Costs per Acre of Tomatoes: Hand Harvested, Salinas Valley, California.	31
3	Budgeted Operations and Costs per Acre of Tomatoes: Machine Harvested, Salinas Valley, California.	33
4	Seed Price Per Pound for Tomato Varieties Adapted to Mechanical Harvest, 1965.	36
5	Yield Data for Mechanical Harvest Tomatoes Adapted to the Salinas Valley, California.	40
6	Comparison of Differences in Preplanting Costs for the Hand and Machine Harvest Models.	48
7	Comparison of Differences in Growing Costs for the Hand and Machine Harvest Models.	51
8	Machine Harvest Costs Varying with Production for a 14 Sorter Machine at 7.5 Tons per Hour Output and a 21 Sorter Machine at 10.0 Tons per Hour Output.	58
9	Relationship Between Tons per Acre Machine Production and Tons per Acre Field Yield Assuming 75 Total Acres, Eight Working and Seven Production Hours per Day.	61
10	Summary and Comparison of Tomato Enterprise Costs per Acre for Hand and Machine Harvest Models.	64
11	Summary of Sales for Hand and Machine Harvest Models.	66

Appendix Table		Page
1	Calculations for Over-tolerance and Rejected Tomatoes for Hand and Machine Harvest Models.	77
2	Data for Machine Harvest of Tomatoes	78
3	Gross Receipts per Acre of Tomatoes and Calculation of Net Price per Ton for Hand and Machine Harvest Models.	79

THE ECONOMICS OF MECHANICAL HARVESTING OF TOMATOES IN THE SALINAS VALLEY, CALIFORNIA

CHAPTER I

INTRODUCTION

Mankind presently is living in an age of wondrous inventions. It is often thought that the industrial revolution is over, but this is far from true as far as agriculture is concerned. This is an age of industrial revolution, but not in the sense that most people would be inclined to think of it. The agricultural industry is presently undergoing the stress and strains of mechanization felt by many of the more "urban" type of industries years ago.

Mechanization in agriculture is making farm jobs simpler, accomplishment faster, and some of the functions of man in the industry unnecessary. It is commonly thought that the problems of labor management and cost are bringing the industrial revolution to agriculture and speeding the conversion to mechanization. In the canning tomato industry this would appear to be true as mechanization of harvest, an aspect of the industry thought to be impossible a few years ago, is taking place rapidly. The individual maintaining that something cannot be done is now finding himself interrupted by the person who is doing it.

A few years ago the idea of mechanical harvesting was completely out of the question with the varieties of tomatoes available at that time. Plant breeders have opened new vistas of possibilities with the development of determinate varieties having a high percentage of fruit ripening at one time and which are suitable to commercial production in addition to relatively rough handling by machines. With new varieties of tomatoes to work with, Agricultural Engineers were able to develop machines that will harvest the tomato crop.

Statement of the Problem

The question of economic feasibility of mechanical tomato harvesting does not seem to have been formally worked out by the canning tomato industry in California. But judging from the actions of the industry it would appear that it is feasible as mechanization is well underway and seems to be here to stay. The individual grower is still confronted, however, with the problem of deciding whether to mechanize his operation and how he will make such a change. There are many factors which the grower must consider in arriving at his decision.

This thesis is concerned with a study of the economics of mechanically harvesting tomatoes in the Salinas Valley of California. The principal objective being to bring out and discuss some of the economic problems faced by growers shifting from hand to machine harvesting of tomatoes. Also, the related cultural requirements of the crop for machine harvest will be examined from the standpoint of the requirements and conditions of the Salinas Valley.

Method of Study

The use of mechanical tomato harvesters is a very new development and economic data related to their operation and use are limited. During the 1964 tomato harvest season there were only three machines located in the Salinas Valley of which only two were in full operation. With such a small sample it would be difficult to obtain primary information that would be significant. In spite of the small number of machines, detailed economic information was not available from these growers. Limited cost and operational information is available from machine manufacturers and growers who are using the new machines in other parts of the state. Cultural data are readily available through publications of the California Tomato Growers Association and Agricultural Extension Service of the University of California, Davis. This information has been extensively used in the preparation of this thesis. Other data were obtained through personal correspondence with fieldmen, seedsmen, and growers who are either directly or indirectly involved with the culture and machine harvest of tomatoes. Considerable data on the physical characteristics of various machines were obtained from their manufacturers as well as from trade journals. Finally, the writer has drawn heavily upon first-hand knowledge derived from being associated with growing tomatoes on his father's farm in the Salinas Valley, California.

Literature

Literature was sought in an effort to locate economic cost studies on the operation of mechanical tomato harvesters and on the culture of the varieties adapted to machine harvesting. This search produced only one cost study of the machine harvest operation which was developed by the University of California Agricultural Extension Service (29). No economic cost studies were found pertaining to the cultural aspects of the machine harvest operation. Economic studies are more readily available on the culture and harvest phases of hand harvest enterprises and several cost studies were obtained (12, 18, 22, 23, 40, 42).

A substantial portion of the current work with mechanical tomato harvesters is being done in California. However, considerable research on the use of mechanical tomato harvesters and bulk handling of tomatoes has been done by Michigan State University. Although the varietal selections developed are not directly adapted to California conditions, the work is a significant development (31). The data on bulk handling methods developed by Ries and Stout at Michigan are valuable and have been utilized by the California canning tomato industry (32, 33).

CHAPTER II

CULTURE AND HARVEST OF TOMATO VARIETIES ADAPTED TO MECHANICAL HARVEST

New tomato varieties have been developed for machine harvesting as the standard hand picked varieties are not adapted or suited for machine harvesting. The fruit is too soft, does not mature at one time, and the vine growth is too abundant to be handled through a machine. Varieties adapted to machine harvest are smaller plants with thick skinned fruit which tends to mature at one time. Machine harvest tomato varieties adapted to the environment of the Salinas Valley are discussed in this chapter in addition to examining various required cultural operations.

Tomato growers are presently finding that a chain of management and cultural factors ranging from the rate of seeding to irrigation intensity are linked together and affect the maturity of machine harvested tomatoes. The cultural practices used have a direct impact on the yield of the crop at harvest. Weed control, cultivation, fertilization, and irrigation must all be timed properly to avoid delaying or stimulating plant growth at an ill suited time. Reduced yields and possibly increased harvest costs may result from poorly timed and planned operations. In addition to discussions of the various cultural aspects in this chapter, preparation for harvest also is considered as well as the harvesting operation and factors affecting the quality of the resulting product.

Varieties

Tomato varieties suitable for mechanical harvesting must be thick skinned and firm in order to withstand rough handling by a mechanical harvester. Fruit must be set during a short period so that a high percentage of the fruit will ripen at the same time. A small determinate plant with a concentrated fruit set is required. The plants also must be resistant to verticillium and fusarium wilt and be able to set fruit under a wide range of temperatures. Good holding qualities on the vine are required. Other factors which are considered are the pH, solids, color, core size, fiber, and wholeness which are very important to the processor (37).

Presently there are two varieties of tomatoes which can be cultivated for mechanical harvesting, VF 145's and the pearshapes, which may be hand harvested if necessary. The VF 145, a verticillium and fusarium wilt resistant early canning variety, is very popular. Certain strains of the VF 145 variety are now being recommended for culture in the Salinas Valley as mechanical harvest types and are known as the VF 145-B, VF 145-B-8, VF 145-21-4, and VF 145-7879 (5, 6, 9).

The VF 145-B strain is well adapted for machine harvesting and is noted for its uniform ripening characteristics (9). It has a green shoulder type of fruit which has a yellow-butt problem in warm years (13). This strain is the firmest of the 145 variety with good color development. Machine damage is quite low, however, one test indicated 18 percent of the stems remained on the fruit which makes the product undesirable for whole pack processing (36).

Another type of the VF 145-B strain is the VF 145-B-8 a popular green shouldered strain (5). The fruit set tends to be more concentrated than the VF 145-B, matures a few days earlier, and handles well through the machine (13).

The VF 145-B-7879 strain of the green shouldered series also has good coloring characteristics and harvests quite satisfactorily. It is much like the B-8 strain in that it too has a more concentrated maturity than the 145-B, matures a few days earlier, and machine harvests well (13). The solids level is high, it has a small core, and yields a fairly high tonnage per acre (36).

Another very promising strain is the VF 145-21-4 which is well suited to machine harvesting and is thought by some to be the best available at the present time. The fruit is very firm, deep-round, and has a small stem scar (35). It does not harvest as well as the green shouldered strains however (43). The ripening behavior is erratic and it is susceptible to grey-wall and yellow-butt disorders according to King (13). There is a low amount of fruit dropping before harvest, a relatively low percentage of stems remaining on the fruit, and a very low level of machine damage to the fruit. For these reasons it is recommended for whole pack processing (36).

The variety of fruit planted on a given farm will depend on the use the processor has intended for the product and will usually be stipulated in the contract. Other selections are available which are also suited to the conditions of the Salinas Valley and should be tried on an experimental plot basis in order to be familiar with their characteristics.

Row Spacing and Field Size

The conventional planting of tomatoes in the Salinas Valley consists of single rows of plants thinned to 12 to 14 inches on 60 inch centers. Machine harvest varieties are smaller plants and are usually planted as double rows on 60 inch beds. A wide bed is required to keep the vines and fruit out of the furrows and in a position for easy pick up by the harvesting machine. In using the 60 inch beds, two rows of plants are spaced 12 to 14 inches apart to give an increased number of plants per acre, about double that of single rows. The greater plant population promotes more uniform maturity, better vine coverage, more efficient machine handling, increased yield, and less cull fruit (4). Irregular growth and maturity result in high numbers of green fruit at harvest time which must be removed on the sorting belts as culls (19).

Field size will depend on the amount of land available for the crop in the rotation program. The field size also will depend on the number of harvesting machines to be used and the length of the harvest season. Fields should be divided into blocks which can be harvested in ten days or less by one machine. Ten days is about the longest time that the fruit will remain at maximum harvest maturity (19). While the size of blocks recommended varies from 25 to 50 acres, the most frequent recommendation is about 25 acres. In the event that weather conditions speed up the maturity of the crop or machine harvesting problems arise, the grower would most likely be able to complete the harvest of the smaller acreages without incurring financial loss through over-ripe fruit. As a safety factor the block sizes should be conservative.

Seedbed Preparation

General land preparation practices will not change when the mechanical tomato harvest varieties are grown. The practices used will vary with the soil type, but will be the standard methods employed in the areas. Typically, most land preparation involves chiseling or plowing, discing and harrowing combined, and a leveling operation. Bed shaping is perhaps the most critical phase of the seedbed preparation. The beds must be of uniform width and flat with no depressions.

Flat beds are essential if all the fruit is to be picked up by the harvesting machine. Smooth, flat beds, free from clods are necessary for the best planting conditions (37). Rough, uneven beds make planting at a slower rate necessary to avoid skips, possible damage to the planting units, and excessive machine wear. However, with some soil types found in the Salinas Valley, it is more desirable to have beds in a fairly rough condition rather than too smooth. This is particularly true when planting early in the season when rains may occur. Crusting usually results from a rain storm and prevents plant emergence. Experience has shown that the finely prepared seedbeds are more susceptible to crusting and the problem can be partly corrected by the rougher type of seedbed.

Planting Dates

Planting dates may be stipulated by the processor with whom the grower has contracted the crop. In the event that the dates are not set by the processor it will be up to the grower to choose dates that will best fit into this plan of work and sufficiently space the harvesting periods of each block to permit harvesting as optimum maturity occurs. The first planting may be made any time during the period of March 1 to April 15. Plantings made during this time will mature at about the same time and should be regarded as one block (37, 39). Cooler temperatures early in the season delay the time of emergence and slow the rate of plant growth.

Research workers in California have found that maturity rates from emergence for the new varieties of tomatoes are nearly the same when seeded between April 1 and June 1. Plantings made during this period generally take from 125 to 130 days from plant emergence to harvest maturity (19). During this period of time spacing of plantings for continuous harvest can be accomplished by planting the blocks every two weeks or by using the three-leaf stage of the last block planted as an indicator. The method giving the longest time should be used.

Seeding and Thinning

Seeding rates suggested by the University of California, Davis for single row plantings are one-half to three-fourths of a pound of seed per acre or 12 to 20 seeds per foot with double rows requiring up to one pound of seed per acre (37). Other recommendations range from one to two pounds per acre for the double row spacing (5, 19). Sufficient seed should be used to insure an adequate stand of plants after damping off, insects, and other seedling disorders take their toll.

Double rows of plants spaced at 12 to 14 inches should be thinned to a 10 to 12 inch spacing within the row (6). A staggered plant spacing between double rows is recommended to made for the best overall machine operation by allowing a more continuous flow of plant material into the machine (15). Present recommendations state that thinning should be done as soon as the second or third leaf shows to eliminate plant competition and avoid root damage (37). Thinning traditionally is done in a manner so as to break up all clumps and leave single plants in the rows. Recent studies in the San Joaquin Valley by King have shown that it is not necessary to break clumps into singles as multiples of two to four plants will produce as a single plant (14). Considerable savings may be possible by using either a mechanical thinning device or a not-so-accurate type of hand thinning. The conventional method of hand thinning requires the worker to separate the clumps and leave single plants spaced more or less equidistant down the row. If the thinner was not required to leave individual plants at all times the thinning operation would become simply a blocking process and could be done at a much faster rate.

Weed Control

Weed control is an important aspect of the tomato cultural program for mechanical harvesting. Good weed control is essential from the standpoint of eliminating plant competition for space as well as plant nutrients. Weeds may tend to stunt some seedlings and make for uneven growth causing irregular maturity and lower yields (19).

When twin row plantings of tomatoes are used, weed control becomes more difficult to accomplish. Mechanical cultivation between the double rows of plants becomes difficult due to the nature of the plant locations. Cultivation must be shallow in order to avoid possible damage to the small, shallow root system which is characteristic of the new plant varieties.

Chemicals are available which may be used as pre-plant or pre-emergence herbicides. Broadcast applications are more expensive due to application and material costs, but control weeds over a greater area. The present trend is to band a strip about 24 inches wide over the center of the bed for double row plantings.

Should weeds be discovered after planting, but before the tomatoes emerge, Stoddard solvent may be applied with good results. A broadcast application would require 40 to 50 gallons per acre and a band treatment about ten gallons per acre (37).

Fertilizer

Fertilization of the new varieties of tomatoes for mechanical harvesting is different only in two respects from the procedure used for the standard hand picked varieties. Timing of the applications is more critical and the quantity of material used is generally less. Other aspects of the fertilization program are essentially the same.

Present recommendations for the mechanical harvest varieties are for eight to ten pounds of actual nitrogen and 10 to 20 pounds of phosphorous per acre applied as a pre-plant with the larger amounts being used on heavier soils (37). The general accepted method of pre-plant fertilizing in most areas is to apply a liquid fertilizer such as 8-24-0 at the rate of about ten gallons per acre while listing (9).

Additional nitrogen is usually applied to the new varieties at the time of thinning as late applications of nitrogen can stimulate secondary growth. Fruit set later in the season does not mature at the same time as the earlier set clusters and must be removed as green fruit on the sorting belt. The effects of heavy nitrogen fertilization on tomatoes are shown by succulent vine growth, irregular fruit set, and irregular fruit maturity (19). If additional nitrogen is to be applied it should be done at the time of thinning, or earlier, and sidedressed at the rate of 60 to 80 pounds per acre (37).

Irrigation

The careful control of irrigation practices is necessary for tomato varieties that are harvested mechanically. Heavy irrigation produces responses similar to those created by heavy applications of nitrogen fertilizer. Plants should be kept growing continually and not stressed for moisture at various times during the growing period. Two stages of growth are especially critical; one occurring during blooming and the other at the approach of fruit ripening. Should the plants be stressed for moisture during either of these periods the yields could be seriously affected.

The VF 145 selections have a smaller, more shallow root system than the standard hand picked varieties and thus require more frequent irrigations. Adequate supplies of soil moisture are needed to promote good vine growth in order that the plants may bear a normal crop of fruit. This period of abundant moisture should be followed by a period of a lesser amount of soil moisture to encourage fruit setting by limiting nitrogen availability to the plant (19).

Research on fertile Central Valley soils has shown that a single heavy irrigation in addition to the post-thinning irrigation is adequate to produce maximum yields. Irrigating after the first clusters have started to ripen will induce a secondary blooming and another fruit set which will appear at harvesting as green fruit and will have to be removed on the sorting belt (19).

Irrigation management also affects fruit quality. Research indicated that yields of fruit from plots last irrigated just after thinning were reduced ten percent below treatments receiving more irrigations. These dry plots, however, had a 15 percent concomitant increase in soluble solids and were less susceptible to cracking injuries by the harvester (19).

Cultivation

Mechanical cultivation of varieties of tomatoes to be mechanically harvested is essentially the same as for hand picked varieties. The process of cultivation should be for the specific purpose of promoting growth and therefore should be done in a manner so as to avoid injuring the plant by root pruning and thereby slowing the rate of growth. By cultivating, the grower is attempting to accomplish two objectives. First, to control weeds and second, to build and maintain the beds. Weed control should be practiced continually throughout the cultural program, but will not be as critical near the plants if a herbicide has been used in that area. It is also necessary to move the soil into the area between and around the plants after mechanical thinning. Furrows will need to be cleaned out and beds reconstructed after thinning. Furrow irrigation will cause a certain amount of erosion and filling which can be corrected during the cultivation process.

Clods should be broken up during cultivation before the soil is moved into the area around the plants. As the plants develop it is especially important to avoid moving clods into the vine area as they may be picked up by the harvesting machine. Their presence may cause fruit damage in addition to increasing the amount of mud formation in the machine and on the product.

From the standpoint of machine efficiency, cultivation should be combined with other operations in the cultural program, such as fertilization, where possible, to reduce the number of trips over the field.

Insect Control

The insect control program for the machine harvest varieties of tomatoes is essentially the same as for the hand harvested crop. Control requirements vary depending on the location and the insects which may be a problem in the area. Tomatoes must be closely watched at the time of emergence as cutworms are usually the first problem. However, in some years early infestations of sugarbeet webworm may exist in the Salinas Valley (30). DDT and Phosdrin are applied as the first treatment to control these insects. If the potato tuber worm is found, Gunthion would be added to the first treatment. This spray is normally applied by ground equipment unless field conditions preclude any ground work. In the event that reinfestations continue, the treatment of DDT, Phosdrin, and Gunthion is repeated at the setting of the first fruit.

As the vines increase in size, applications of Methyl parathion and sulphur dust are usually made by air. Phillips has found that this method of control in the latter stages of abundant vine growth is very effective for the control of thrips, tuber worms, corn ear worms, and the ubiquitous russet mite (30).

Nonparasitic Disorders

There are two nonparasitic disorders of tomatoes which can have a definite impact on the net yield of the tomato crop. These disorders affect both the machine and hand harvested varieties of tomatoes, but their presence can be more serious with a machine harvest operation. Grey wall, blotchy ripening, and internal browning are three of the common names used to describe the first of these disorders. This nonparasitic disorder is characterized by uneven ripening of the fruit wall in circular or irregular whitish green areas. Dead tissue surrounding the small vascular bundles is frequently visible in these irregular areas and is seen as a brownish-grey discoloration. These dead areas can be easily seen when the wall of the fruit is cut away (11). The exact cause of this disorder is not known at this time, but it is well established that several environmental factors such as cool temperatures, deep shade of vines, high humidity, and perhaps excessive fertilizer enhance the possibilities for the occurrence of the disorder (11).

The second disorder closely resembles grey wall and to the inexperienced it is difficult to distinguish the difference (7). Yellow-butt or green-butt as it is commonly called, also is characterized by the fruit failing to ripen as it should. This disorder is less serious from an economic viewpoint as grade standards are more tolerant of yellow-butt than grey wall. The cause of this disorder from all indications is due to cooler environmental temperatures (9). Both grey wall and yellow-butt are to a certain extent, typical of the cooler coastal areas with grey wall being prevalent in all areas during certain years (7).

State inspection is required of every load of tomatoes shipped to canneries in California. The total amount of defects cannot exceed 15 percent of the load by weight. If both of the disorders discussed are present in the field it is difficult for the sorters on the machine harvester to be able to distinguish the difference between them. Excessive amounts of either of the disorders will make it virtually impossible for a given number of sorters on a machine to remove enough of the defective fruit to bring the product within tolerance. A grower faced with these conditions would find that it is impossible for him to machine harvest. During the 1964 harvest season one grower in the Salinas Valley was faced with this problem as about 40 percent of the fruit had grey wall and some yellow-butt. In this case the sorters were unable to sort out the quantity of affected fruit required to meet the 15 percent tolerance limit. Exceeding the tolerance automatically caused rejection of entire loads and total economic loss resulted as it was not possible to regrade the bins of tomatoes. By machine harvesting and sorters failing to remove the required quantity of affected fruit a 100 percent production loss was resulting. Under circumstances such as these, machine harvesting was not economically feasible. In this situation the grower reverted to a hand picking crew to finish the harvesting with only a 40 percent production loss.

Harvesting

Preparation for Harvesting

Preparation of the field for harvesting will begin during the early stages of the cultural program as beds must be level and uniform in spacing. Furrows need to be uniform in depth and at harvest time should be dry and firm to provide support for the weight of the harvesting machine. Row headlands should be smooth, level, and dry with at least 30 feet allowed for turning of the machine. The length of the rows in most cases is governed by the field size and shape, but should be at least 1, 000 feet long for efficient machine operation. The maximum length will depend on the yield and the number and capacity of trailers available for hauling of the tomatoes. In the event the rows are too long, the field may be split to provide shorter rows.

In addition to the harvesting machine, it will be necessary to have a means of transporting the harvested fruit from the field. Bulk bins are used in the majority of cases, but boxes are used to some extent where the harvesting machine is equipped to fill them. The typical bin trailer will carry five or six bins in a single row, is pulled by a wheel tractor, and is equipped with a hydraulic unloading device. A forklift truck also will be needed to handle the loaded bins in a loading area. Some growers have purchased their own forklift, but the present trend is to lease or rent these machines for the harvest period. Other equipment usually required are portable toilets and a water souce for washing the machine in the field. Drinking water will be required and is best carried on the machine.

A loading or staging area is required and needs to be in a central location near the field easily accessible to paved roads. The staging area should be located so as to minimize the travel time for the bin trailers. Two tractor-trailer bin handling units will be required to haul the tomatoes from the field and if the distance is too great, a third unit may be required to eliminate expensive waiting time by the harvesting machine. This area also needs to be of sufficient size to accommodate the empty bins, full bins, over-the-road truck or trailers, and to permit maneuvering of the fork truck along with the bin trailers.

The procurement and training of the sorters who ride on the harvesting machine must be done before the preparation for harvest is complete. These people are essentially the key to the growers success in delivering a quality product. Both men and women may be employed for this type of work and experience on the part of growers has shown that a steady turnover in personnel can be expected (3).

Sorters must be trained before the harvest operation begins so that they will know exactly what they are supposed to do. Before they get on the machine they should be shown the fruit defects they are likely to encounter and which are to be discarded. One of the sorters should be delegated to serve as supervisor and be responsible for maintaining the quality of the product flowing from the machine. This person is stationed near the discharge elevator and controls the speed of the machine which in turn governs the quantity of fruit passing in front of the sorters.

Training of other personnel is also necessary if the grower is to have a smoothly running operation. The machine operator should be familiar with all functions of the machine and the entire harvesting operation. Tractor drivers pulling the bin trailers should know exactly what they will be required to do as well as the operator of the fork-lift. In addition to each person in the operation knowing what is expected of them, they should also have a concept as to the goals of the grower in terms of quality and quantity of output. It is especially important that the sorters be aware of the financial implications involved with the rejection of a load of tomatoes.

Operation

Harvesting operations should be started early to avoid excessive over-ripe fruit which is easily damaged. Soft tomatoes, subject to pressure by the rough handling of the machine, readily rupture and produce juice which, when combined with the dust and dirt prevalent in the harvesting operation, results in mud. The net result is a fouling of the machine in addition to creating a poor quality product.

Determining when to begin harvesting is best accomplished by pulling a few plants, shaking off the fruit, and counting. Ripe fruit tend to be hidden by the foliage and unobserved, which makes the field appear to be less mature than it actually is. Harvest operations should be started when the field is about 65 percent mature as in three to four days the field maturity in most cases will be in the neighborhood of 90 percent.

Several days are usually required, once harvesting is started, for the operation to become a smooth working unit. Efficiency of operation will improve as the employees become accustomed to their work and gain proficiency. Skill on the part of the machine operator is required if maximum efficiency to be achieved. Stopping and starting unnecessarily do much to reduce efficiency as well as tending to increase trash accumulation on belts and conveyors. Turning into rows should be made smoothly without backing up or stopping to reduce the amount of time lost.

Equipment inspection and maintenance should be done during times that will not put the entire operation at a standstill. Maintenance work can be done during rest or lunch periods, or more ideally before or after normal working hours. This type of work is usually most efficiently accomplished by two people working together. Typically the machine operator and a helper will do this work in addition to their regular duties.

Product Quality

A high quality product will be free of harvest dirt, cracks, bruises, and mud smears, and will be delivered to the processor as soon after harvest as possible. Bin filling should be done carefully to avoid bruising or cracking the fruit by starting with the discharge chute close to the bottom and gradually raised as the bin fills. Daily harvesting operations should not begin until the dew is off of the vines to reduce the amount of moisture collected in the machine and thereby increase the possibility of producing a clean, high quality product. Machine washing may be necessary on a daily basis and should be done as often as needed to keep the machine clean. Mud is the biggest problem faced in many instances and quickly reduces the quality of the product.

Fruit at high temperatures continues to ripen and soften in the bins. When harvesting under high temperature conditions, rapid product delivery is essential if losses are to be minimized and quality maintained. Where temperatures are high and product maturity is rapidly advancing, night operations may be required. By installing lights on the harvesting equipment it should be possible to complete harvesting of the field before optimum maturity is surpassed.

CHAPTER III

DEVELOPMENT OF ECONOMIC MODELS

Procedure

The economics of mechanical tomato harvesting is studied by the use of economic models. Cultural aspects are also shown in the models as they affect yields and harvesting requirements. In examining the differences in the economic aspects between hand and machine harvesting, a model has been constructed for each and the two compared. These models are divided into culture and harvest, which are further subdivided as necessary for explanation.

Certain assumptions have been made to establish the basic framework within which each model is structured. Each model is built using the same physical and environmental resources, varying only those factors changing with a shift from hand picking to mechanical harvesting. Current price and cost data are used as well as standard rates of operation and cultural methods typical to the Salinas Valley. Although the costs and returns shown may not be exact or illustrative for a given situation, it is felt that certain basic relationships are demonstrated and that these models closely parallel typical situations as presently exist.

In order to provide limits and conditions within which the models are constructed, each model is constructed for 75 acres of rented land and both are for the same year on a given ranch. The tomato enterprise is assumed to be part of an existing diversified operation and it also is assumed that an acceptable crop rotation program is being followed. The soil selected is fairly heavy in structure and typical of the Salinas Valley. Water is available in the quantities required for irrigation from underground sources and is of a desirable quality. Rainfall and weather conditions are assumed to be normal for the area along with disease and insect problems. Adequate quantities of labor, qualified to do the required work, is assumed to be available. Machinery and equipment is available for most of the cultural operations and is used on other enterprises as well. Some operations are normally done by commercial firms and are charged at standard rates. Capital is available in the quantities required to finance the crop and make any capital expenditures required for machinery. Yields are assumed to be normal and contracts are held for the sale of the end product. Other assumptions are stated in appropriate places for purposes of explanation and clarification.

Equipment Costs

Equipment costs are based on the assumption that the 75 acre tomato enterprise is a part of a 500 acre diversified operation. The equipment inventory includes those pieces of equipment which are essential to the culture of tomatoes in a manner characteristic of the Salinas Valley (Table 1). A larger total inventory would actually be found on a 500 acre operation than is shown as multiples of certain pieces of equipment would be required. Cost calculations are based on typical acreages or hours of use that would be expected from a single machine under normal conditions.

Depreciation is calculated by the straight line method for all equipment. Interest and taxes are figured as a percentage of the average value. The original value of the machine forms the basis upon which the storage and insurance costs are computed. Fractional percentages of 0. 75 and 0. 25 respectively are used. Variable costs such as repairs, and grease and service are likewise calculated as three percent and one percent of the original value of the machine. Fuel is based on hours of use and consumption per hour. Oil costs are structured from the estimated gallonage required for the hours of operation assumed. Total costs of operation are expressed as a total per hour or per acre; the more convenient manner of expression being used where possible.

Labor Charges

Hourly labor charges in the models are based on the wages presently being paid in the Salinas Valley. The present rate for tractor drivers is $1. 85; irrigators $1. 55, and hand labor $1. 40. These

Table 1. Projected Equipment Inv
Acre Farm. Salinas Vall

	Method of Computation	andplane 10'	Ring Rollers 10 & 12'	Harrow 3-4'	Bedshaping Equipment	Cultivator Bars & Tools	Planting Units
A. Purchase price, $		2, 500	1, 100	150	1, 600	1, 500	250
B. Salvage value, $		250	110	10	160	150	25
C. Average value, $	A+B ÷ 2	1, 375	605	80	880	825	138
D. Depreciable balance, $	A-B	2, 250	990	140	1, 440	1, 350	225
E. Useful life. yrs		15	10	10	10	8	8
F. Fuel per hour. gal.							
G. Annual use - hours							
H. - acres		1, 000	1, 000	500	500	500	75
1. Depreciation	D ÷ E	$150	$ 99	$14	$144	$169	$25
2. Interest	C x 6%	82	36	5	53	50	9
3. Taxes	C/4 x 7%	24	10	2	15	14	2
4. Storage	A x 0. 75%	19	8	1	12	11	2
5. Insurance	A x 0. 25%	6	3		4	4	
6. Total Fixed	Σ 1 - 5	$281	$156	$22	$228	$248	$38
7. Fuel - Gas	F x G x $0.:						
8. - Diesel	F x G x $0.						
9. Oil	Gal x $1.3(						
10. Repairs	A x 3%	75	33	4	48	(5%) 75	8
11. Grease & service	A x 1%	25	11	2	16	15	2
12. Total Variable	Σ 7 - 11	$100	$44	$6	$64	$90	$10
13. Total Cost	6 + 12	$381	$200	$28	$292	$338	$48
14. Total Cost per hour	13 ÷ G						
15. Total Cost per acre	13 ÷ H	$0. 38	$0. 20	$0. 06	$0. 58	$0. 67	$0. 64

wages include all benefits and constitute the total amount typically being paid by growers in the Salinas Valley.

Wages of farm employees in this area are over 25 percent higher this year and pickers are expected to be rather scarce at harvest. In view of this fact a piece rate of 22 cents per box is judged to be a realistic cost for hand pickers and is used in the model (Table 2). Loaders are expected to receive a proportionally higher wage for their work which is computed to be two and one-half cents per box. Labor for the mechanical harvest operation is priced in light of present conditions and trends (Table 3). Sorters are expected to receive \$1.45 per hour; the supervisor \$1.55; the forklift operator \$2.00; and the machine operator \$2.50 per hour. These wage rates are the total amount paid by the grower and include all benefits.

Preplanting Operations

The preplanting operations for the hand and machine harvest models are essentially the same. General tillage operations are assumed to be performed by a 60 horsepower crawler tractor and rates of performance are based on standard acres per hour of operation. The tractor and labor charges are structured from these rates of performance. Equipment costs are charged by the acre. Two operations are combined where possible for the purpose of increasing the efficiency of tractor and equipment use. The listing and preplanting

Table 2. Budgeted Operations and Costs per Acre of Tomatoes: Hand Harvested, Salinas Valley, California.

Operation	Hours per Acre	Cost per Acre, Dollars: Labor	Tractor	Equipment	Other	Total per Acre
Preplanting Costs						
Disc & Harrow (2X)	0.5	0.92	1.79	1.14		$ 3.85
Chisel & Roll (2X)	0.8	1.48	2.86	0.90		5.24
Level (2X)	1.0	1.85	3.57	0.76		6.18
Springtooth & Roll (2X)	0.7	1.30	2.50	1.00		4.80
List - Preplant, Contract					3.00	3.00
Fertilizer - 300 lbs 16-20-0 @ 4¢/lb.					12.00	12.00
Bedshape	0.4	0.74	0.51	0.58		1.83
Total Preplanting Cost						$36.90
Growing Costs						
Planting	0.8	1.48	1.02	0.64		3.14
Seed 3/4 lb. @ $9.00/lb.					6.75	6.75
Thinning	15	21.00				21.00
Cultivate & Furrow (5X)	2.5	4.62	3.18	0.67		8.47
Irrigate (6X)	15	23.25		1.64	1.50	26.39
Water 2.5 ac.ft. @ $5.20/ac.ft.					13.00	13.00
Sidedress Fertilizer (2X)					3.00	3.00
Fertilizer, 600 lbs. 10-10-5 @ 3¢/lb.					18.00	18.00
Pest Control, Contract					25.00	25.00
Hoe & Weed	20	28.00				28.00
Grader	0.5	0.92	0.84			1.76
Misc. Overhead					20.00	20.00
Total Growing Cost						$174.51
Total Cost of Culture						$211.41

Table 2. Continued.

Operation	Hours per Acre	Cost per Acre, Dollars: Labor	Tractor	Equipment	Other	Total per Acre
Harvest Costs						
25 tons/acre x 42 boxes/ton = 1050 boxes/acre						
Picking, 22¢/box		231.00				$231.00
Loading, 2.5¢/box		26.25				26.25
Box rent. 1¢/box					10.50	10.50
Inspection, 18¢/ton					4.50	4.50
Rejected Loads					1.32	1.32
Labor Overhead, 3¢/box					31.30	31.30
Harvest Overhead, 2¢/box					21.00	21.00
Total Harvest Cost						$325.87
Other Costs						
Association Dues. 10¢/ton					2.50	2.50
Rent, 20% gross receipts					144.35	144.35
Total Other Cost						$146.85
Total - All Cost						$684.13

Table 3. Budgeted Operations and Costs per Acre of Tomatoes: Machine Harvested, Salinas Valley, California.

Operation	Hours per Acre	Cost per Acre, Dollars: Labor	Tractor	Equipment	Other	Total per Acre
Preplanting Costs						
Disc & Harrow (2X)	0.5	0.92	1.79	1.14		$ 3.85
Chisel & Roll (2X)	0.8	1.48	2.86	0.90		5.24
Level (2X)	1.0	1.85	3.57	0.76		6.18
Springtooth & Roll (2X)	0.7	1.30	2.50	1.00		4.80
List - Preplant, Contract					3.00	3.00
Fertilizer, 10 gal/acre 8-24-0 @ 40¢/gal					4.00	4.00
Bedshape	0.5	0.92	0.64	0.58		2.14
Herbicide, Contract					3.00	3.00
Material - Dyiamid. 31b/acre @ $2.50/lb					7.50	7.50
Total Preplanting Cost						$39.71
Growing Costs						
Planting	1.6	2.96	2.03	0.64		5.63
Seed 1 lb./acre @ $11.44/lb.					11.44	11.44
Thinning	25	35.00				35.00
Cultivate & Furrow (5X)	2.5	4.62	3.18	0.67		8.47
Irrigate						
Sprinkler (2X)	3.0	4.65		6.58		11.23
Furrow (4X)	10.0	15.50		1.64	1.50	18.64
Water 2.5 ac.ft. @ $5.20/ac.ft.					13.00	13.00
Sidedress					1.50	1.50
Fertilizer, 225 lbs./ac. Ammonium Nitrate @ 5¢/lb.					11.25	11.25
Pest Control, Contract					25.00	25.00
Hoe & Weed	15	21.00				21.00
Grader	0.4	0.74	0.67			1.41
Misc. Overhead					20.00	20.00
Total Growing Cost						$183.57

Table 3. Continued.

Operation	Hours per Acre	Cost per Acre, Dollars				Total per Acre
		Labor	Tractor	Equipment	Other	
Total Cost of Culture						$ 223.28
Harvest Costs						
Sorters 14 @ $1.45/hr	3.8	77.14				77.14
Supervisor $1.55 hr	3.8	5.89				5.89
Forklift	3.8	7.60		10.67		18.27
Trailers (3)	3.8	21.09	12.57	4.60		38.26
Machine, 7.5 tons/hr	3.8	9.50		75.38		84.88
Chemical toilets				1.07		1.07
Inspection, 18¢/ton					4.50	4.50
Rejected loads						1.18
Bin Rental, 40¢/ton					10.00	10.00
Misc. Overhead					3.25	3.25
Machine Overhead	0.47	2.04				2.04
Total Harvest Cost						$246.48
Other Costs						
Association Dues 10¢/ton					2.50	2.50
Rent, 20% gross receipts					142.65	142.65
Total Other Costs						$145.15
Total - All Costs						$614.91

application of fertilizer is assumed to be contracted at the rate of three dollars per acre plus the material. The per acre application charge for this operation is assumed to be the same for both models with the amount and cost of fertilizer applied varying. It is assumed that approximately 300 pounds per acre of 16-20-0 is applied to the hand harvest variety and ten gallons per acre of 8-24-0 to the machine harvest varieties. Bedshaping follows the listing operation and is projected as being done by a 30 horsepower wheel tractor. The operation is assumed to require 0. 4 hours per acre to complete for the hand harvest model. Bedshaping for the machine harvest model is assumed to require an additional 0. 1 hour per acre, or 0. 5 hours per acre total, since each bed must be more carefully prepared. A preplanting herbicide also is assumed to be applied to the mechanical harvest field in a 24 inch wide band over the center of the bed. The cost of this operation is based on a three dollar per acre contract application charge plus three pounds of chemical per acre at $2. 50 per pound.

Seed Price

Seed prices for the standard hand picked varieties grown in the Valley are fairly uniform and typically $9. 00 per pound. Some variation can be found, but the majority of the seed lots sell at this price. Seed for the standard varieties is charged at $9. 00 per pound in this study.

Seed prices for selections adapted to mechanical harvesting vary considerably depending upon the length of time the selection has been available for multiplication. Some strains are available from several seed companies, while others can be purchased only from one company in which case the price may tend to be higher. Prices for the seed selections used in this model range from $7.00 to $15.00 per pound (Table 4).

Table 4. Seed Price Per Pound for Tomato Varieties Adapted to Mechanical Harvest, 1965.

	Price Per Pound					
	Source					Used in
Seed Selection	1	2	3	4	Average	Model
VF 145-B	$12.00		$7.00		$ 9.50	$ 7.00
VF 145-B-8		$12.50		$12.50	12.50	12.50
VF 145-21-4	12.00	12.50	9.00	12.50	11.50	9.00
VF 145-7879				15.00	15.00	15.00

The 75 acre field is split into four blocks which are planted with four seed selections recommended for this area. Three of the blocks are 20 acres in size and the fourth consists of 15 acres of VF 145-21-4. It has been assumed that the seed costs per pound are $7.00 for the VF 145-B, $9.00 for the VF 145-21-4, $12.50 for the VF 145-B-8, and $15.00 for the VF 145-B-7879. The seed charge used is an acre-weighted average of the various seed prices, plus sales tax. Calculated on this basis, the seed charge for the mechanical harvest model is $11.44 per pound.

Growing Costs

Hand Harvest

The growing costs in the hand harvest model are based on a number of standard operations. Planting is assumed to take 0.8 hours per acre to accomplish and requires one man, one wheel tractor, and the necessary tractor mounted planting equipment. Thinning typically requires about 15 man hours per acre, which is used in this model, but may vary considerably depending on weed conditions and the ability of the thinning crew. The number of cultivations and furrowing operations also vary with weed conditions, but is assumed to require five in the hand harvest model and a total of 2.5 hours for each acre. The crop is assumed to require six irrigations, 15 man hours, and 2.5 acre feet of water. Sidedressing of fertilizer is done two times by a commercial firm at a cost of $1.50 per acre per application in addition to a total of 600 pounds per acre of 10-10-5 fertilizer. Pest control requirements vary with the degree of infestation, but are assumed to be normal. Control of insects is charged as a fixed amount per acre as if performed on a contract basis. Hoeing and weeding costs depend on the amount of weeds present and the accuracy of the cultivation operations. Typically about 20 man hours are required over the course of the growing period for this operation and are thus assumed. Other costs of culture include the use of a grader for the preparation of the borders of the field for irrigation and cultivation, and a miscellaneous overhead charge. This overhead charge includes items such as the use of the pickup, telephone, movement and setup of equipment, and accounting fees.

Machine Harvest

The growing costs for the mechanical harvest model are structured on the basis of standard operations and the special requirements of the machine harvest varieties. Planting is assumed to take 1.6 hours per acre and is accomplished with the use of tractor mounted planting units. Thinning costs are based on 20 hours per acre required to complete the operation. Furrow and sprinkler irrigation are used in the irrigation program for the mechanical harvest varieties. The first two irrigations are assumed to be by sprinkler as the furrows are too far away from the plant rows to be efficiently used. Four furrow irrigations follow after the plants have a developed root system. Cultivation and furrow maintenance is done a total of five times. Sidedressing of fertilizer is done only once after thinning using 225 pounds per acre of ammonium nitrate applied commercially at a cost of $1.50 per acre plus the material. Since a preplant herbicide has been applied, the man hours required for hoeing and weeding are assumed to be 15 hours per acre. The use of a grader requires about 0.4 hours per acre and is used before and after each irrigation for the maintenance of the row ends. Miscellaneous cultural costs are budgeted at $20 per acre and cover pickup use, telephone, accounting, and other miscellaneous cash costs.

Factors Affecting Harvest Costs

Several factors which affect the total costs for the hand and machine harvest operations are discussed in the following section. Variety, yield, product inspection and sales contract, and the amount of defective fruit are examined from the standpoint of their effects on total harvest cost.

Varieties and Yield

Selections of the VF 145 variety most widely recommended by growers and seedsmen for the Salinas Valley are the B, B-8, B-7879, and the 21-4. These are the selections used in the machine harvest model. Yields for these mechanical harvest varieties vary with location and the source of the data (Table 5). Parsons (29) of the University of California, Davis reported yields on ten Central Valley farms for the VF 145-B selection ranging from 14 to 30 tons per acre with an average of 22.2. Trials by one seed company produced yields of 37.8 and 45.8 tons per acre with this same selection (35, 36).

Other studies indicated yields varying from 19.5 to 36.3 tons per acre for the varieties used in this model (13, 43). Yields in the King City area for VF 145-B and 21-4 have been about 18 tons per acre, but are forecast by Hayes (10) to increase. Another grower in the Salinas Valley reported yields of 20 tons per acre with the B and 21-4 selections (41).

In light of the past production records for the varieties in the Central and Salinas Valleys and considering the improvement in forecast yields, this model is constructed on the assumption of a 25 ton per acre yield.

Table 5. Yield Data for Mechanical Harvest Tomatoes Adapted to the Salinas Valley, California.

	Data Source[1]					
Variety	1	2	3	4	5	Average
	Yield in tons per acre					
VF 145-B	19.5	25.5	33.0	18.0	20.0	23.2
VF 145-B-8	22.6	24.4	35.5			27.5
VF 145-21-4	20.6	23.9	26.3	18.0	20.0	21.8
VF 145-7879	22.1	25.5	33.7			27.1
						24.9

[1](10, 13, 41, 43)

Product Inspection

The Tomato Inspection Service of the California State Bureau of Fruit and Vegetable Standardization is required by law to examine and grade all lots of tomatoes shipped to canneries for processing. Allowable percentages have been established for each type of defect that may be found by State Inspectors on processing tomatoes (2). This standard applies to both hand and machine harvested tomatoes. Random samples are taken for inspection and the percentage of defective fruit in the load is calculated. Loads of tomatoes which have over 15 percent defective fruit are rejected by the State Inspector as being unfit for processing and are returned to the grower. The maximum allowable percentage of defective fruit which the processor will accept is typically 15 percent, as established by the State, but may be lower depending on the needs of the processor. It is assumed that in these models the maximum amount of defective fruit permitted by the processor is 15 percent as stated in the contract.

Product Sales Contract

The models for hand and machine harvesting presented in this thesis are constructed on the assumption that a contract is held with a processor which gives the grower a market for his product at a specified price. The at-farm sales price is assumed to be $30.00 per ton for tomatoes in both models. Some contracts are currently being made in the Valley at this price, but prices are generally unsettled for the 1965 harvest season. A typical contract agreement is assumed in that boxes or bins are furnished by the processor and rented to the grower. Hauling from the farm to the processing plant is paid for by the processor. Transportation of tomatoes rejected by the state or processor from the point of rejection back to the farm is paid by the grower.

Contracts usually contain the provision that tomatoes shipped to the processor having a state grade from zero to five percent defective fruit are bought at the contract price without dockage. Lots having more than five percent defective fruit but not exceeding 15 percent by state inspection, are accepted by the processor, but docked by the amount the defective fruit exceeds the five percent tolerance limit. The weight of the defective fruit exceeding the five percent tolerance limit is paid for at the rate of $1.00 per ton. The balance of the lot is purchased at the stipulated contract price. A typical provision such as this is assumed to apply to the models constructed in this thesis.

Over-tolerance and Rejection of Fruit

As has already been stated, tomato lots grading from 5 to 15 percent defects are not rejected, but the excessive defective fruit is paid for by the processor at $1.00 per ton instead of $30.00. The average amount of defective fruit in lots received by California processors in recent years has run about eight percent (12). Therefore, defective fruit has exceeded the tolerance limit of five percent by three percentage points. This means that three percent of the total weight of lots delivered to the processor would be paid for at $1.00 per ton. The analysis reported herein is based on an average of eight percent defective fruit for both hand and machine harvest models. Assuming that 25 tons per acre are delivered, three percent or 0.75 tons are sold for $1.00 per ton as over-tolerance fruit.

The amount of fruit lost by rejection varies with the area, climatic conditions, harvest supervision, and the time of the season. For purposes of this studyit is assumed that 1.75 percent of the fruit picked is lost by rejection. The cost of returning the rejected loads to the grower is $2.00 per ton. Other costs also are incurred. Rejected loads can either be regraded at the cost of $1.00 per ton or dumped, depending on the amount of bad fruit. Losses can be minimized by regrading at the farm in most cases and saving a portion of the tonnage. Under usual circumstances, at least 50 percent of the tonnage can be salvaged. Costs for the return haul and regrading amount to $1.32 per acre (Appendix Table 1) and are charged against hand harvest expense in this study. The saleable fruit after regrading amounts to 0.22 tons per acre and is sold for $30.00 per ton or $6.60.

It is also assumed that two percent of the mechanically harvested tomatoes are rejected and must be dumped at a cost of $0.35 per ton (Appendix Table 1). Assuming 25 tons per acre production, 0.5 tons per acre are rejected. The return haul cost is $1.00 per acre and dumping amounts to $0. 18 per acre which are charged against the machine harvest expense in the model.

Harvest Costs

Hand Picking

Harvest costs for hand picking are structured on the assumption of a 25 ton per acre yield, which is equivalent to 1, 050 boxes per acre calculated on the basis of 42 boxes per ton. Picking costs are projected at 22 cents per box and comprise the greatest portion of the total cost of harvest. Loading also is on a per-box basis amounting to two and one-half cents. This includes the necessary time spent by the loaders distributing empty boxes. Box rent is another harvest cost which is typically charged by the processors at one cent per box. The second most significant harvest cost is entered as labor overhead and calculated at three cents per box. This charge takes into consideration labor supervision, transportation, checkers, and contractors commission. Other miscellaneous harvest costs are covered by a two cent per box charge and includes such items as drinking water, equipment, and field clean up after harvest.

Machine Harvest

The costs of machine harvesting of tomatoes developed in this model are structured on the basis of several assumptions (Appendix Table 2). It is assumed that a total of 75 acres are harvested with a yield per acre of 25 tons. Machine output is assumed to be 7.5 tons per hour operating seven actual hours per day. Employees are paid on the basis of eight working hours per day. From these data certain other statistics are calculated which are used to determine the cost of harvest per acre. The production in terms of tons per day is calculated to be 52.5 requiring 3.3 machine production hours per acre. Employee working hours, on the basis of an eight hour day, amount to 3.8 hours per acre. Fourteen sorters, one supervisor, three tractor drivers, one forklift operator, and one machine operator make up the harvest work force. Labor charges then are structured on the basis of 3.8 hours per man per acre. The tractor costs are figured on the basis of 3.3 hours per acre. The harvesting machine, forklift, trailers, and chemical toilets are charged on a per acre basis. It is assumed that the forklift and chemical toilets are rented for two months, at a cost of $400 and $40 per month respectively, with maintenance and service included in the charge. Inspection of the shipped product is charged at 18 cents per ton and bins are rented from the processor for 40 cents per ton. Miscellaneous harvest operational costs are charged at $3.25 per acre and include costs such as pickup, telephone, bin loading area preparation, and water. Machine overhead covers the maintenance of the machine and equipment by the machine operator and one tractor driver each working one hour per day in addition to the regular eight hour day. The per acre charge for machine maintenance is calculated to be $2.04 on the basis of 2.1 acres per day harvested.

CHAPTER IV

DISCUSSION OF ECONOMIC MODELS

In Chapter III an economic model was developed for a typical machine harvest operation. A model also was developed in the preceding chapter representing a typical hand harvest situation in the Salinas Valley. The economic models for the hand and machine harvest tomato enterprise also include sections on cultural aspects up to planting and through the growing period.

It is now appropriate in this chapter to compare the two harvesting methods. This is accomplished by first considering the preplanting phases of the hand and machine harvest models and then comparing the growing costs. Hand harvest costs are then compared with the synthesized costs of machine harvesting at the assumed level of performance. The discussion of the machine harvest operation is subdivided into major segments for purposes of closer examination in the concluding portion of the chapter.

Preplanting Costs

Preplanting costs structured for the hand harvest model total $36.90 per acre compared to $39.71 for the machine harvest model. The machine harvest model costs for fertilizer, bedshaping, and herbicide total $16. 64 per acre. Charges for the hand harvest model fertilizer and bedshaping total $13. 83 per acre. A comparison of the differences in preplanting costs for the hand and machine harvest models is shown in Table 6. All other preplanting costs are equal for both models. From the figures structured in these models it is evident that the preplanting costs for the machine harvest model are $2. 81 per acre more expensive than for the hand harvesting model. This difference of less than three dollars per acre is not considered significant as variations in preplanting costs of this magnitude would be expected among growers in the area regardless of the harvest method.

Table 6. Comparison of Differences in Preplanting Costs for the Hand and Machine Harvest Models.

Item	Hand Harvest	Machine Harvest	Difference
Fertilizer	$12. 00	$ 4. 00	$ 8. 00
Bedshaping	1. 83	2. 14	+0. 31
Herbicide		10. 50	+10. 50
Total	$13. 83	$16. 64	$+2. 81

Hand Harvest Model

Preplanting costs shown in the hand harvest model tend to be higher than figures typically found in tomato crop cost studies. The total hours per acre required for this phase of the cultural program are comparable to rates typically used. Budgeted labor costs are higher by about 25 percent, as previously discussed, and account for part of the cost difference. Tractor costs are charged on the basis of fixed and variable costs per acre of use and tend to be higher than those normally used. Typically, depreciation and interest are charged as general overhead expenses in published reports and are not included as a part of the direct tractor charge (12, 18, 23, 42).

Costs for the preplanting operations shown in the hand harvest model are based on techniques used in the Salinas Valley and adjusted to present labor cost conditions. Although various elements are not presented in the usual classification framework, it is felt that the relationships shown are representative of the average preplanting program for tomatoes hand harvested in the Valley.

Machine Harvest Model

The same comments regarding equipment costs in the hand harvest model hold for the basic preplanting elements in the machine harvest model. Bedshaping costs as shown may tend to be slightly higher than those incurred by some growers depending on the equipment and method employed, soil moisture conditions, and soil texture. In some cases multiple bed equipment may be used. The herbicide charge likewise may vary depending on the material applied, rates of application, and area treated. Occasionally the herbicide incorporation is combined with the bedshaping operation which reduces the total cost of both operations.

Preplanting costs resulting from the relationships shown in the machine harvest model are considered fairly representative of conditions to be found in the Salinas Valley. Some of the elements shown are identical for both the hand and machine harvest models. Other operations differ with the cultural requirements of the crop and the methods necessary to insure successful machine harvest. Detailed data are not available at the present time with which to compare the developed model with the experiences of a large number of growers. The results, however, are considered to be realistic.

Growing Costs

The total growing cost of the hand harvest crop as structured for the model amounts to $174.51 per acre. Growing costs for the machine harvest model total $183.57 per acre. Table 7 provides a comparison of the growing costs which differ between the hand and machine harvest models. Structured costs other than those shown are the same in both models.

Planting, seed, thinning, and irrigation are more costly for the machine harvest system; fertilizer, weed control, and grader costs are lower than those for the hand harvest model. These costs are lower as less fertilizer is required; hand weed control requirements are reduced by the herbicide, and sprinkler irrigation does not require the use of the grader. The growing costs developed for the machine harvest model are $9.06 per acre more expensive than for the hand harvest model. The cost difference is not great. However, it is to be expected that the growing costs incident to machine harvest varieties would be higher. Total cultural costs for the machine harvest varieties normally range from the same to $25.00 per acre higher than for the hand harvested varieties (10). As structured in the machine harvest model, the preplanting cost is $2.81 per acre higher and the growing cost is $9.06 per acre above that for the hand harvest model. This additional cost of culture of $11.87 per acre is well within the expected range of $0 to $25 per acre and is regarded as reasonable.

Table 7. Comparison of Differences in Growing Costs for the Hand and Machine Harvest Models.

Item	Hand Harvest	Machine Harvest	Difference
Planting	$ 3.14	$ 5.63	$+2.49
Seed	6.75	11.44	+4.69
Thinning	21.00	35.00	+14.00
Irrigation Labor and Equipment	26.39	29.87	+3.48
Fertilizer and Application	19.50	11.25	-8.25
Hoe and Weed	28.00	21.00	-7.00
Grader	1.76	1.41	-0.35
Total	$106.54	$115.60	$+9.06

Hand Harvest Model

Tomato growing costs shown for the hand harvest model are well in line with area cost studies and grower records (22, 23). However, costs experienced by any particular grower could be lower or higher than illustrated and would depend upon management and practices employed.

Planting cost depends on the method used and could be more or less expensive than the cost structured in the machine harvest model. The thinning cost presented in the model is typical of grower experiences. Hoeing and weeding costs would be lower than those shown if a preplanting herbicide were employed. However, such a practice is not general in the Salinas Valley for hand picked varieties. Irrigation has been assumed to be by furrow for all applications as it is the standard practice in the Valley. Sprinklers could have been used which would change the cost elements of the model, but the total costs would be approximately the same. The cost per acre foot of water at $5. 20 may be considered high, but in a situation where the typical lift is about 100 feet and booster pumps must be employed, the charge is judged to be in line with the circumstances and grower experiences. Fertilizer costs would vary from the illustration depending on the amount and cost of the chemical used, but would not differ greatly from the estimates shown.

Machine Harvest Model

Growing costs for the machine harvest model are considered to be realistic. However, there are no cost studies available at this time on the culture of the new varieties adapted to machine harvest for purposes of comparison. No specific data are available to indicate the time required for planting which makes an estimation necessary. Seed costs are structured on the basis of an acre-weighted average price which amounts to $11.44 per pound. However, recent information indicates that growers are actually paying $15.00 per pound for seed. This cost affects only the machine harvest model and is not counterbalanced in the hand harvest model. As a result, the growing costs are underestimated for the machine harvest model by the amount of the difference between budgeted and actual seed costs. Thinning costs check with those experienced by growers in the Valley (41). Total irrigation costs are considered typical for the area, but would vary with location and the methods employed. No grower data are available with which to check the fertilizer cost, but the charge shown is structured on the basis of University of California recommendations (37). Hoeing and weeding hours per acre are estimated. Since a preplanting herbicide is used it is reasonable to assume that the time required for this operation would be minimized.

Costs and rates of operation modelled for the machine harvest growing costs are structured using the best information available at the present time. Prices and costs experienced by growers in the Salinas Valley may vary somewhat from the figures shown in the model, but the deviation most likely will not be great.

Harvest Costs

The discussion of harvest costs is divided into two major areas for purposes of examination. Hand harvest costs, mainly labor expenses, are examined first. Machine harvest costs are then discussed in considerably more detail by subdividing the subject into discussions of labor cost relationships and the harvesting machine.

Hand Harvest

Labor costs comprise the greatest portion of the total cost of harvest for the hand harvest model. Picking costs are based on a forecast charge of 22 cents per box. This charge may be overestimated and could be as much as four or five cents more than will actually be paid by the time the 1965 harvest begins. In the event that the supply of labor is more limited than estimated, the piece rate paid could possibly be higher than forecast. Should the U. S. Department of Labor find it advisable to permit Mexican Nationals to be used, the piece rate could drop to lower levels typical of past years. Based upon present forecasts concerning the labor situation, it is felt that this charge of 22 cents per box is a reasonable estimate of the rate that will be paid.

Box rent is charged at one cent per box. If the total supply of tomatoes to the canneries is short, this charge could possibly be dropped. In some instances box rent is not charged which in effect is the same as increasing the contract price to the grower.

The labor overhead charge for the hand harvest model is based on the assumption that a labor contractor supplies the facilities for the housing of the picking crew as growers in the Salinas Valley typically do not maintain crew housing facilities. On the basis of this assumption, the overhead charge made for this model is considered reasonable. In the event the grower maintains his own camp, the charge would, in all probability, have to be higher.

Inspection of the tomatoes is charged at the standard rate. Loads failing to pass inspection and are rejected are charged at $1.32 per acre as previously explained in Chapter III.

The total cost of hand harvest is $325.87 per acre, which is high by standards of past years. However, when the additional costs of labor are taken into consideration, the costs indicated in this model are reasonable. Costs of hand harvest as shown may be high or low depending upon labor supply and piece rates charged, but are best estimates based on evaluation of current information.

Machine Harvest

Labor. Based upon the system budgeted for this model, about one-half of the total costs of machine harvesting are for labor. This model is constructed on the assumption that 14 people are required to remove the cull fruit in addition to the other required crew members.

Another type of harvesting machine used in the area has stations for 21 sorters, which, if required and used, would increase the labor cost in this model by an additional $37. 24 per acre. Assuming that the machine output per hour is equal to the 14 sorter machine and that the increased size of the sorting crew could remove enough cull fruit to have zero rejects, the amount saved would be 0. 5 tons per acre at a value of $16. 18 per acre. If the assumption also is made that the additional sorters will be able to lower the percent of defective fruit to five percent or less of the delivered product, the value of this savings of 0. 75 tons per acre is $22. 50. Other factors being equal, it would appear that the use of the additional labor will save the grower $16. 18 in rejected loads, $22. 50 in over-tolerance fruit, and net $1. 44 per acre over the additional cost of wages. However, the percent defective fruit characteristically is about six percent with this type of machine which would be a reduction of only 0. 5 tons per acre at a value of $15. 00 (10). The savings calculated on this basis is $16. 18 in rejects, and $15. 00 in over-tolerance fruit which fails by \$6.06 to equal the additional cost of the labor. With other factors held constant, it is evident that the use of the increased number of sorters may not be profitable in some instances.

Another comparison can be made between the 14 and 21 sorter machines by examining the costs, mainly labor, that vary with different levels of machine production. Accepting output of the 14 sorter machine at 7.5 tons per hour, as structured in the machine harvest model, the costs affected by the level of production total \$133.79 per acre (Table 8). Although experience among growers indicates that 7.5 tons per hour is typical of the output of each machine, the total costs varying with output become \$131.47 per acre when the output of a 21 sorter machine is assumed to be ten tons per hour. Other costs of harvest, including rejects and the percent of defective fruit, are assumed to exist in approximately the same proportions between the two types of machines and having no affect on this comparison. From these figures it can be seen that the 21 sorter machine must have an increased output of almost 2.5 tons per hour over the 14 sorter machine in order to offset the cost of the additional seven sorters.

The machine operator is paid the rate of \$2.50 per hour in this model. Some growers pay the machine operator the same rate as a tractor driver (41). A per ton rate is sometimes used by growers as an incentive for high production (10). Regardless of how the machine operator is paid, this person must be highly skilled and competent, and commands a high salary or ample bonus in return for his work.

Table 8. Machine Harvest Costs Varying with Production for a 14 Sorter Machine at 7.5 Tons per Hour Output and a 21 Sorter Machine at 10.0 Tons per Hour Output.

Item	Cost per Hour	Hours per Acre	Cost
14 sorter machine at 7.5 tons per hour production			
Labor			
Sorters (14)	$1.45	2.9	$88.30
Supervisor	1.55	2.9	4.50
Forklift operator	2.00	2.9	5.80
Tractor drivers (3)	1.85	2.9	16.10
Machine operator	2.50	2.9	7.25
Tractors (3)	1.27	2.5	9.52
Total			$131.47
21 sorter machine at 10 tons per hour production			
Labor			
Sorters (21)	$1.45	3.8	$77.14
Supervisor	1.55	3.8	5.89
Forklift operator	2.00	3.8	7.60
Tractor drivers (3)	1.85	3.8	21.09
Machine operator	2.50	3.8	9.50
Tractors (3)	1.27	3.3	12.57
Total			$133.79

The number two man on the machine harvest crew is the forklift operator who is responsible for keeping the machine supplied with bins. In this model the wage paid is $2.00 per hour. This person may be paid the same rate as a tractor driver, but in most instances receives a higher wage.

Labor costs as structured in the model are based on wages presently being being paid with the working hours per acre calculated on the basis of assumed rates of production typical to machine harvesting.

Harvesting Machine. The per acre cost of owning and using the harvesting machine is based on 75 acres of annual use. In this model the costs aggregate to a $75. 38 per acre (Table 1) for the machine, which includes both fixed and variable costs.

It is assumed that the investment cost of the machine is $19,479 and the salvage value is $500. Calculated from these figures, the depreciable balance is $18, 979, which is spread over a five year period. It is not known at the present time whether the economic life of the harvesting machine will be five, ten or possibly 15 years. At the rate technology is advancing, it is safe to assume that the economic life of the machine models presently in use will be short due to technological obsolescence. The machine could be obsolete in less than five years, but at the present time the true answer is not known. Assuming a ten year life, instead of five years as calculated, the annual depreciation is lower and thus the per acre charge for use is lower. The per acre cost of ownership and operation calculated on a ten year life is $50. 08. Increasing the period of useful or economic life has a great impact on the annual cost.

The salvage value of the machine also is difficult to predict as presently no one knows what the value will be at some future time. Ten percent of the original value could have been used which would have increased the salvage value and decreased the yearly depreciation. By increasing the salvage value to ten percent, the annual per acre cost of the machine becomes $70. 52.

The machine output is assumed to be 7. 5 tons per hour of operation. This rate of production is regulated by the capacity of the sorters to remove the desired amount of defective fruit and the actual yield of the field. Machine speed down the row can be regulated to partially adjust for variations in yield and thus help to maintain a constant quantity of fruit passing in front of the sorters. Table 9 illustrates the effect of changing the output of the machine and the yield of the field. A field yielding 25 tons per acre will require 3. 8 working hours to harvest at 7. 5 tons per hour of machine output and 2. 9 working hours at an increased output of ten tons per hour. The effect of increased machine output is expressed as a reduction in the harvest cost per acre. With a given rate of machine production, high yielding fields will naturally require more production hours per acre. Assuming 7. 5 tons per hour production and a 30 ton per acre yield, 4. 0 production hours will be required for harvest. If production could be increased to ten tons per hour, the hourly requirement would drop to

Table 9. Relationship Between Tons per Acre Machine Production and Tons per Acre Field Yield Assuming 75 Total Acres, Eight Working and Seven Production Hours per Day.

	Tons per hour production					
	7.5			10		
	Tons yield per acre					
	20	25	30	20	25	30
Tons per day	52.5	52.5	52.5	70	70	70
Production hours per acre	2.7	3.3	4.0	2.0	2.5	3.0
Working hours per acre	3.0	3.8	4.6	2.3	2.9	3.4
Acres per day harvested	2.6	2.1	1.8	3.5	2.8	2.3
Days per field	29	36	43	21	27	33
Total production hours per field	203	242	301	147	189	231

3. 0 hours. The effect of production per hour and total yield per acre can also be seen in the measures of acres per day harvested, days per 75 acre field, and total production hours per field as shown in Table 9.

Field yield as well as rates of production are expected to vary to some degree among blocks of tomatoes harvested on any particular ranch in the area. The assumption of a 25 ton per acre yield and 7. 5 tons per hour harvested production for the machine harvest model are made recognizing the fact that these are average figures typical to the Salinas Valley.

Comparison of Hand and Machine Methods

Hand picking harvest costs structured in the model total $325.87 per acre compared to $246. 48 per acre for machine harvest. Practically all of the costs for hand picking are for labor expenses, while less than one-half of the machine harvest costs are for labor.

The cost of picking labor has a significant affect upon the total cost structure of the hand harvest model. Costs vary depending on the piece rate paid. The hand picking costs for the model are structured on forecast piece rates of 22 cents per box for picking and 2. 5 cents per box for loading. Assuming the piece rates remain typical of past years at 18 cents per box for picking and two cents per box for loading, the total cost for hand harvesting would be $278. 62 per acre. This cost is still greater than that of machine harvesting at

7. 5 tons production per hour. In order for the total costs of the two methods to equate, the rate of hand picking would have to be reduced to approximately 16 cents per box with loading at 1. 5 cents per box. However, the likelihood of such a drop is remote.

Machine harvest costs most likely will be lowered as production per hour is increased with improved technology. If machine production per hour is assumed to be ten tons per hour instead of 7. 5 tons, the total cost per acre for harvest is $219. 47, other costs held constant. Future increases in the output of harvesting machines are realistic and are likely to occur in light of current technology. Labor costs for personnel employed for machine harvesting will continue to increase, but at a rate much less than that for hand harvesting labor.

Summary of Costs

The total of all costs--preplanting, growing, harvest, and other-- as structured for the hand harvest model are $684 per acre and $615 per acre for the machine harvest model. A summary and comparison of the major cost elements for the two models are shown in Table 10. Total costs developed for the machine harvest model are $69 per acre less than the total costs for the hand harvest model. Preplanting and growing costs are more expensive for the machine harvest enterprise, but harvest and other costs are less costly.

Other costs are composed mainly of the land rental charge. In both models it is assumed that this charge is 20 percent of the sales. This rental rate is rather high, but seems to be typical of the Valley where a straight cash rent is not charged. This charge affects both models in approximately the same magnitude.

Table 10. Summary and Comparison of Tomato Enterprise Costs per Acre for Hand and Machine Harvest Models.

	Costs		
Item	Hand	Machine	Difference
Preplanting	$ 37	$ 40	$ +3
Growing	174	184	+10
Harvest	326	246	-80
Other	147	145	-2
Total	$684	$615	$-69

The total costs for the modelled hand harvest enterprise are structured within the framework of conditions and requirements for the Salinas Valley and are judged typical of costs to be found in the area. Costs for the machine harvest model are constructed using the same requirements and limitations. However, less detailed information on growers practices and experiences has been available on which to base the machine harvest model. The physical requirements and rates used are structured on the best evidences available and are thought to be entirely representative.

Revenue

Effects upon revenue must be examined as well as the impact on the cost structure of the operation in order to determine the economic feasibility of a new harvest method. A summary of the product sales for the hand and machine harvest models is shown in Table 11. Gross receipts for the hand harvest model are $722 per acre and $713 per acre for the machine harvest model. The gross receipts are indicated as being slightly less under conditions prevailing for machine harvest, but the total costs are sufficiently lower to more than double the net revenue for the machine harvest tomato enterprise. Net revenue for the hand harvest model amounts to $38 per acre after expenses of $684 per acre are deducted from gross receipts. A net revenue of $98 per acre remains after the machine harvest model expenses of $615 per acre are subtracted from total revenue. From these calculations the effect of the machine harvest method on net revenue is easily seen.

The difference in total tons per acre recovered and the gross revenue per acre between the two harvest methods is not great. Dumping of rejected fruit in the machine harvest model, as a result of being unable to salvage a portion of the rejected tonnage, accounts for the difference in revenue per acre. The tons of product sold total 24. 78 per acre for the hand harvest model and 24. 50 per acre for the machine harvest model. Net price received per ton also is essentially the same as calculated in Appendix Table 3 and amounts to $29.12 for the hand harvested product and $29.11 for the machine harvested tonnage.

Table 11. Summary of Sales for Hand and Machine Harvest Models.

Sales	Price	Tons	Value
Hand harvest model			
Prime and Resorted	$30.00	24.03	$720.90
Over-tolerance	1.00	0.75	0.75
Total		24.78	$721.65
Machine harvest model			
Prime	$30.00	23.75	$712.50
Over-tolerance	1.00	0.75	0.75
Total		24.50	$713.25

Price and yield variables could alter the results of the relationships shown if a change in either variable affected only one of the enterprise models. The price received per ton of product could change to favor one of the tomato types. In the event that equal pricing does not prevail, the relationships shown would be altered considerably. Assuming that no tomatoes were rejected in the machine harvest model, the gross receipts would be higher. More rejects than assumed would lower gross receipts and increase costs which would narrow the spread between net receipts of the two models. Labor could also be more plentiful and costs not as high as structured which would place the hand harvesting method in a more favorable position.

Although many variables could be altered which would affect the gross revenue for each of the models, the revenue relationships illustrated have been established on the basis of existing prices, conditions, and trends. The difference in net revenue per acre of $60 in favor of machine harvesting is sizeable. On a planting of 75 acres, this amounts to $4,500 greater net returns per year and would more than equal the purchase price of the machine in five years.

CHAPTER V

SUMMARY AND CONCLUSIONS

Summary

Harvesting tomatoes with a machine is a relatively new development but is rapidly becoming more common in the California tomato canning industry. Only limited information is available on the cost of machine operation and the culture of varieties adapted to mechanical harvest. Presently only fragmentary economic data are available pertaining to the entire cost structure of a mechanical harvest enterprise.

In order to examine the economics of mechanical tomato harvesting, two economic models were developed comparing hand and machine harvest methods. Data were gathered from growers in the area, individuals in service industries, and from published material. The models were structured for a farm of a given size and acreage devoted to the culture of tomatoes. Equipment costs were structured on the basis of equipment typically used on a farm of the assumed size and required for the necessary cultural operations.

The cultural requirements of the varieties of tomatoes adapted to mechanical harvest that differ from hand harvested varieties have been discussed as well as the harvest procedures and practices required. Cultural operations and procedures for the machine harvest varieties were kept within the framework of the environmental conditions of the Salinas Valley.

The two economic models were developed on the basis of standard practices for the hand harvest variety and the practices discussed for the machine harvest varieties. Labor costs were based on wages currently being paid as well as forecast rates. Growing conditions were assumed to be normal. Yields were structured on the basis of grower experiences and are assumed to be typical. Other costs in the models were structured on the basis of actual or projected charges.

The discussion of the economic models was divided into sections beginning with preplanting costs, which were found to be $37 per acre for the hand harvest model and $40 per acre for the machine harvest model. Hand harvest model growing costs were $175 per acre compared to $184 per acre for the machine harvest model. Budgeted harvest costs for the hand and machine harvest enterprises were discussed in considerable detail and found to total $326 and $246 per acre respectively. A comparison of the hand and machine harvesting methods was made and costs of culture and harvest summarized. The total costs for the hand harvest model were found to be $684 per acre and $615 per acre for the machine harvest model.

The effects of harvest methods on revenue were examined in addition to the economic cost structure of the enterprise. Gross receipts were found to be $722 per acre for the hand harvest model and $713 per acre for the machine harvest model. Net revenue was $38 and $98 per acre respectively. A net advantage of $60 per acre for machine harvesting is shown.

Conclusions

Several conclusions may be drawn from the comparison of hand and machine harvesting of tomatoes as presented in this thesis. As structured in the models, total costs of growing and harvesting an acre of tomatoes for machine harvesting are less than when had picking is practiced. Less labor is required and the type of labor required is probably easier to obtain, as sorting generally is considered a higher classification of work than picking. Production per man hour involved in the harvest operation is much greater under mechanical harvesting. This is of particular significance where labor is in short supply and wages high. Machine harvest is more flexible as working hours are relatively easy to adjust to compensate for variations in plant maturity. Night harvesting also is possible when harvesting machinery is equipped with lights. Existing cultural equipment can be utilized in growing the machine harvest varieties and costs of culture are approximately the same as for hand harvest varieties.

The size of acreage required to justify machine ownership may render mechanical harvesting prohibitive for some growers. Under conditions and assumptions outlined in this thesis, 38 acres of tomatoes is about the point where total costs for machine and hand harvest equate, which indicates that machine harvesting becomes economically feasible at this point. The capital requirements for the harvesting machine are high which results in high fixed costs. These fixed costs must be spread over a large tonnage of tomatoes if economical harvest is to be achieved.

The hand harvest method has certain desirable characteristics as does machine harvesting. Capital requirements for harvesting equipment are practically negligible which provides a grower with limited capital other investment opportunities, such as fertilizer, that would return greater rewards than the saving resulting from machine harvesting. Regrading of rejected loads is possible when hand harvested as boxes are easily handled and the fruit resorted. The main problem under present conditions is the lack of available labor for the hand picking operation, which creates high labor and hand harvest costs.

Capital requirements for mechanical harvesting equipment is the main limiting factor of mechanized harvest, although the size of acreage required also may be limiting in some instances. Costs of culture for mechanical harvest adapted varieties are slightly higher per acre than for hand harvested tomatoes, but the difference is not great enough to be limiting. Cooperative ownership of mechanical harvesting equipment is possible by two or more growers of rather small acreages of tomatoes which would reduce the per acre cost of harvest by spreading fixed costs over a larger acreage and also would reduce the capital outlay on the part of each investor. In a situation where a large acreage of tomatoes is available to make mechanical harvest very economical, but the growers capital is limiting, a lease-purchase arrangement may prove to be an acceptable means of financing.

It is apparent that increasing mechanication of agriculture is inevitable under present economic conditions. Overall cultural and harvest efficiency of the mechanical harvest enterprise will improve and become less costly with technological advances and improved knowledge. Mechanization of the tomato harvest operation in the Salinas Valley, within the framework of conditions that the two models were constructed, is shown to be economically feasible.

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APPENDIX

Appendix Table 1. Calculations for Over-tolerance and Rejected Tomatoes for Hand and Machine Harvest Models.

Over-tolerance fruit	
Hand and machine harvest models	
Price received over-tolerance product per ton	$ 1.00
Tonnage shipped per acre	25
Assumed percent over-tolerance	3
Tons over-tolerance per acre	
25 tons/acre x 3% =	0.75
Value over-tolerance fruit per acre	
0.75 tons x $1.00/ton	$ 0.75
Rejected Fruit	
Hand harvest model	
Tonnage shipped per acre	25
Assumed percent rejected	1.75
Tons rejected per acre	
25 tons/acre x 1.75% =	0.44
Return haul charge per acre	
0.44 tons/acre x $2.00/ton =	$0.88
Regrading cost per acre	
0.44 tons/acre x $1.00/ton =	$0.44
Tons saleable fruit per acre	
0.44 tons/acre x 50% loss	0.22
Value saleable fruit per acre	
0.22 tons/acre x $30.00/ton =	$6.60
Machine harvest model	
Tonnage shipped per acre	25
Assumed percent rejected	2
Tons rejected per acre	
25 tons/acre x 2% =	0.5
Return haul charge per acre	
0.5 tons/acre x $2.00 =	$1.00
Dumping cost per acre	
0.5 tons/acre x $0.35/ton =	$0.18

Appendix Table 2. Data for Machine Harvest of Tomatoes.

Assumed	
Acres harvested	75
Tons per acre yield[1]	25
Production hours per day (PHrs)	7
Working hours per day (WHrs)	8
Tons production per production hour[2]	7.5
Harvest days per week	5
Calculated	
Tons per day	
7 PHrs/day x 7.5 tons/PHr =	52.5
Production hours per acre	
7 PHrs/day x day/52.5 tons x 25 tons/acre =	3.3
Working hours per acre	
8 WHrs/day x day/52.5 tons x 25 tons/acre =	3.8
Acres per day harvested	
acre/25 tons x 52.5 tons/day =	2.1
Days per field	
75 acres/field x day/2.1 acres = 35.7 or	36
Total production hours per field	
36 days/field x 7 PHrs/day =	242
Weeks per field	
36 days/field x week/5 days =	7.2

[1] Based on yield data tabulated in Table 5.

[2] Structured on limited data and past production records (10, 29).

Appendix Table 3. Gross Receipts per Acre of Tomatoes and Calculation of Net Price per Ton for Hand and Machine Harvest Models.

Sales	Percent Defects	Price per ton	Tons	Value
Hand Harvest Model				
Prime	0 - 5	$30.00	23.81	$714.30
Resorted	0 - 5	30.00	0.22	6.60
Over-tolerance	8	1.00	0.75	0.75
Total			24.78	$721.65
Total tons harvested per acre			25.00	
Net tons lost by rejection per acre			0.22	
Total tons sold per acre			24.78	
Total value sales per acre				$721.65
Net price per ton = $721.65 ÷ 24.78 tons/acre =				$ 29.12
Machine Harvest Model				
Prime	0 - 5	$30.00	23.75	$712.50
Over-tolerance	8	1.00	0.75	0.75
Total			24.50	$713.25
Total tons harvested per acre			25.00	
Net tons lost by rejection per acre			0.50	
Total tons sold per acre			24.50	
Total value sales per acre				$713.25
Net price per ton = $713.25 ÷ 24.50 tons/acre				$ 29.11