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STRAWBERRY PRODUCTION SYSTEM MODEL TO EVALUATE THE ECONOMIC FEASIBILITY OF MECHANICAL HARVESTING AND PROCESSING OF SOLID-SET CULTURE STRAWBERRY PRODUCTION SYSTEMS IN MICHIGAN

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By

Dennis Paul Welch

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ABSTRACT

STRAWBERRY PRODUCTION SYSTEM MODEL TO EVALUATE THE ECONOMIC FEASIBILITY OF MECHANICAL HARVESTING AND PROCESSING OF SOLID-SET CULTURE STRAWBERRY PRODUCTION SYSTEMS IN MICHIGAN

By

Dennis Paul Welch

The Michigan strawberry industry has been on the decline for the past 20 years. In an effort to revitalize the industry, the Michigan researchers and growers used the systems approach technique to mechanize the strawberry harvest and processing industry in Michigan.

The cultural, mechanical, and economic factors have been examined as they relate to the solid-set strawberry production system in Michigan. The current cultural practices are discussed with emphasis placed on the crucial factors which result in the high recovery rate by the harvester. The operational performances for the mechanical harvester and processing equipment are examined.

A strawberry production model has been developed to examine the economic feasibility of mechanical harvesting and processing of solid-set culture strawberry production. The model uses the traditional fixed and variable cost analysis method to establish the ownership and operating costs. All costs in the model are charged exclusively to the strawberry enterprise. The model was validated with grower documentation to estimate the strawberry production costs and net returns. As a result, the model indicates a potential for mechanical harvesting and processing of solid-set culture strawberry production in Michigan. The model shows that when processing the complete raw fruit product as 100 percent puree

with a puree value of 30 cents per pound, that the net cash return per acre to the strawberry enterprise would increase from $31.32 per acre at 6 acres to $2189.57 per acre at 40 acres. The model is sensitive to acreage, machine values, final product price and distribution of the the final product.

APPROVED:

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Major Professor

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Major Professor

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Department Chairman

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List of Abbreviations

ac	-	acre
bu	-	bushel
cm	-	centimeter
CRNDSTY	-	Crown Density
cwt	-	hundredweight
EFC	-	Effective Field Capacity
FE	-	Field Efficiency
FOLHGT	-	Foilage Height
ft	-	feet
ha	-	hectare
hr	-	hour
in	-	inch
kg	-	kilogram
lb	-	pound
m	-	meter
m^2	-	square meter
PCRALL	-	Percent Recovery all fruit
PMHR	-	Projected Material Handling Rate
t	-	tonne
TFC	-	Theoretical Field Capacity
T.I.S.	-	Tax, Insurance, and Shelter
USDA	-	United States Department of Agriculture
yr	-	year

CHAPTER I

INTRODUCTION AND PROBLEM STATEMENT

1.1 Background

Even though commercial strawberry hectares in the United States has been declining for more than two decades (46% decrease), total production has increased by 41 percent. The nation's crop value for 1981 was $310,267,000 an increase of 71 percent over the 1961 crop value (Table 1-1).

The United States produced 335,658 t (370,000 tons) of strawberries in 1981 on 14,812 hectares (36,600 ac). Over 72 percent or 241,674 t (266,400 tons) were sold on the fresh market. The remainder of the production, 92,533 t (102,000 tons) went for processing (USDA,1981).

Presently, only 13 of the 50 states are commercially active in the production of strawberries. The five states leading in strawberry hectares (acres) are; California--4,411 (10,900); Oregon -- 2,226 (5,500); Florida -- 1,295 (3,200); Washington -- 1,133 (2,800); and Michigan --1,093 (2,700) (USDA,1981).

Michigan is ranked second in the nation's production of the spring fresh strawberry market and fourth in the nation's processing market (USDA, 1982). In the years from 1961 to 1981, Michigan was producing between 2.4 and 7.8 percent of the nation's total commercial strawberries

Table 1-1 Trends of area harvested, production, and crop values in the United States.[1]

Year	Harvested Hectares	Harvested Acres	Total Production (100 t)	Total Production (1000 cwt)	Crop Value[2] 1000 dollars
1961	35,770	88,390	2,301	5,073	88,757
1962	35,576	87,910	2,360	5,204	93,728
1963	32,403	80,070	2,313	5,099	95,529
1964	30,291	74,850	2,490	5,490	109,979
1965	27,494	67,940	1,963	4,328	95,836
1966	26,782	66,180	2,106	4,644	103,068
1967	25,779	63,700	2,150	4,740	97,029
1968	23,755	58,700	2,384	5,256	112,010
1969	21,651	53,500	2,205	4,862	109,771
1970	20,639	51,000	2,251	4,963	106,583
1971	19,660	48,580	2,363	5,209	117,005
1972	17,729	43,810	2,079	4,583	109,765
1973	16,536	40,860	2,165	4,773	131,592
1974	16,042	39,640	2,419	5,332	152,759
1975	15,977	39,480	2,458	5,420	165,046
1976	13,941	34,450	2,634	5,807	191,022
1977	14,427	35,650	3,002	6,619	219,958
1978	15,216	37,600	2,990	6,592	209,257
1979	14,690	36,300	2,895	6,383	246,850
1980	14,427	35,650	3,183	7,017	288,776
1981	14,812	36,600	3,356	7,397	310,267

[1]USDA 1977 and 1982

[2]Fresh market price and value on f.o.b. basis.

(Table 1-2). In 1981, Michigan produced 2.4 percent of the nation's strawberries, 78 percent of which were sold in the fresh market.

Table 1-2 Trends of area harvested, yield, production, and percent of U.S. production of strawberries in Michigan[1].

Year	Harvested Hectares	(acres)	Yield/area kg/ha	lbs/ac	Total t	production (1000 lbs)	Percent of U.S. Production
1961	3,399	8,400	4,034	3,600	13,712	30,240	5.9
1962	3,278	8,100	4,707	4,200	15,429	34,020	6.5
1963	3,116	7,700	5,043	4,500	15,714	34,650	6.7
1964	2,954	7,300	5,491	4,900	16,220	35,770	6.5
1965	2,995	7,400	5,155	4,600	15,439	34,040	7.8
1966	2,954	7,300	4,146	3,700	12,247	27,010	5.8
1967	2,752	6,800	4,819	4,300	13,262	29,240	6.1
1968	2,631	6,500	4,595	4,100	12,089	26,650	5.1
1969	2,550	6,300	6,190	5,524	15,784	34,800	7.1
1970	2,347	5,800	4,927	4,397	11,564	25,500	5.1
1971	2,104	5,200	5,388	4,808	11,336	25,000	4.8
1972	1,619	4,000	5,939	5,300	9,615	21,200	4.6
1973	1,376	3,400	4,944	4,412	6,803	15,000	3.1
1974	1,255	3,100	6,399	5,710	8,031	17,700	3.3
1975	1,214	3,000	6,163	5,500	7,482	16,500	3.0
1976	1,174	2,900	6,724	6,000	7,894	17,400	3.0
1977	1,133	2,800	7,844	7,000	8,887	19,600	2.9
1978	1,133	2,800	8,405	7,500	9,523	21,000	3.2
1979	1,133	2,800	7,844	7,000	8,887	19,600	3.0
1980	1,093	2,700	7,305	6,519	7,984	17,600	2.5
1981	1,093	2,700	7,305	6,519	7,984	17,600	2.4

[1]USDA, 1963 -1982

The commercial strawberry hectares in Michigan have been on a steady decline for two decades. Although hectares have been reduced, the yield per harvested hectare has increased. This increase in yield is a result of improved crop technologies such as new and improved strawberry varieties, pesticides, and cultural practices. For example, in 1978, the average yield per harvested hectare was 8,405 kilograms (7,500 lbs/acre), which was almost twice the 1968 yield per harvested hectare. To sum up, in a period of twenty-one years, (1961-1981) Michigan has experienced a 68 percent decrease in its strawberry hectares and only a 45 percent decrease in its total production of strawberries.

Several factors have contributed to the decline of strawberry hectares in the United States. However, the two factors which are the most prevalent are 1) lack of sufficient, reliable harvest labor force and 2) increased harvest costs (Booster, D. E., 1969; Brown, G. K., 1980; Ashcraft, E., 1980; and Duyck, L., 1980).

The migrant labor force is not as stable as it once was; therefore, growers are never sure of the amount of help they will have from day-to-day and year-to-year. This instability of labor has caused some growers to reduce their hectares by one-half to two-thirds (Ashcraft, 1980). The decrease in the harvest labor supply was due to the termination of the Public Law (PL)78, commonly called the "bracero program", and due to the constraints placed upon child labor by child labor laws.

Traditionally, strawberries have been harvested by hand and for all practical purposes they are still highly dependent upon hand labor for harvesting. Brown (1980) reported the amount of labor needed for harvesting is frequently well over 50 percent of the total labor requirement for a specific horticultural crop.

Fridley (1973) reported the two operations which require considerable labor are 1) transplanting and 2) harvesting. A large number of labor hours also are required for irrigation, weeding, and cultivating runners. Harvesting alone, required more labor hours than all other operations combined.

Dennis and Sammet (1961) reported harvesting costs from 14 strawberry producing areas in 10 different states and found harvest costs to range from 47 to 76 percent of the production cost. Alderman et al. (1962), Gobel (1961), and Heater (1967) reported that approximately 50 percent of the total expenditure required for the crop production goes for harvesting costs (reported by Booster et al., 1969).

The future of the Michigan strawberry industry is dependent upon the development of a successful mechanical harvesting system, which will reduce the labor requirements and increase the grower's net income through reduced costs. A few of the Michigan growers have already turned to mechanical harvesting as a means to slow down the production cost increase rate (Grant, 1980, and Ledebuhr, 1982). Michigan's strawberry production system has progressed to the extent that strawberries for freezing and for jams and juice can be mechanically harvested in a once-over operation.

1.1.1 Additional Note

Martin, writing in the October, 1982, Scientific American, stated the need for mechanization in the fruit and vegetable industry nation wide if the United States is to be competitive in its own domestic market. Martin said that the fruit and vegetable industry's growing dependence on the undocumented worker slows the pace of labor saving technological changes needed by the industry if it is to stay viable. This inexpensive alien labor benefits agriculture in the short run but blinds the growers to the needed technological changes which have made the rest of the nation's agriculture a paradigm of efficiency.

Mechanization is one answer to the problems threatening the Fruit and Vegetable industry in the United States. Without mechanization, the U.S. must accept an alien dominated labor force for seasonal handwork and erect trade barriers to keep out produce grown abroad at even lower wages.

1.1.2 Problem Statement

To recommend mechanical strawberry production in Michigan, research must demonstrate that:

1. mechanical harvesting and processing of strawberries can compensate for the decline in the migrant harvest labor force.
2. that the potential revenues will be greater than costs, and
3. income from mechanical strawberry production systems must be sufficient to stimulate potential growers' interest.

1.2 Objectives

The purpose of this dissertation is to examine the economic feasibility of mechanical harvesting and processing of solid-set (Section 3.1) culture strawberries in Michigan.

The specific objectives are:

1) to explain the current cultural practices utilized in solid-set production.

2) to describe the harvester used in this study and its performance.
3) to describe the current processing equipment used in this study and its performance.
4) to develop a computer model to simulate the crop production, harvest, and processing costs for mechanical harvesting and processing of a solid-set strawberry production system.
5) to provide bases for recommending or not recommending mechanical strawberry production in Michigan.

CHAPTER II

REVIEW OF LITERATURE

2.1 Systems Research

2.1.1 Definition and Approach

Systems research is an analytical approach to studying a system as a whole by understanding its subsystems and how their interaction to and/or upon each other has an effect upon the outcome of the complete system. Therefore, systems research deals systematically and rationally with the parameters of the system.

In a systems study there are two major areas of activities: 1) system analysis, and 2) system synthesis. System analysis is the separation of the complete system into its fundamental elements. This involves a thorough examination of the system structure to better understand its nature and to determine its essential features. Systems synthesis utilizes the information gained from the analysis to modify the original system or to design an entirely new system.

Wright (1970) lists the usual sequence of events in a systems research to be:

1) problem specificiation--which leads to a qualitative definition of the relevant system

2) systems analysis -- which attempts to provide a quantitative specification of the system, and
3) systems synthesis--which attempts to give a solution to the original problem.

2.1.2 System Model

Systems research relies heavily on the use of models to replicate the real system. The models are substitutes for the real system and are used as tools to gain further knowledge about the system through analysis and synthesis as the means of conveying information about the system.

Models are used in lieu of the real system for any or all of the following reasons (Miles, 1973): Economy--it may cost less to derive knowledge from the model, availability--the model may represent a system which does not yet exist, and information--the model may be a convenient way to collect or transmit information. Models form an important part of the systems concept because economy, availability, and information are all important factors in the design and analysis of a system.

2.1.3 Model Structure

The three main types of models are; iconic, analogue, and symbolic (Dalton, 1982). Iconic models are physical representations of the real system. Analogue models are based on the use of one property to represent another. Symbolic models are represented by quantitative mathematical symbols. The usual symbols for these models are mathematical ones using algebraic symbols and numbers. Symbolic models are the easiest to manipulate and they force the analyst to be systematic and explicit in the objectives of the model. Once built they can be used for several purposes including planning, control and forecasting.

Models are also classified by behavioral characteristics and degree of complexity. A system may be either deterministic or probabilistic in nature. Each type is then classified by its degree of complexity; simple, complex, or exceedingly complex (Awad, 1979). Deterministic models are predictable in that their outcome is due to the model design and quality and accuracy of the information fed into the system. Probabilistic models are stochastic in nature for they have varying degrees of outcome and are described in terms of chance. For example, a simple probabilistic would be the tossing of a coin (50 percent chances of heads, and 50 percent chances of tails) whereas in a very complex probabilistic system a wide variety of behavior outcomes may exist, such as in a weather prediction model. Therefore, it is extremely difficult to predict with any accuracy the actual outcome or re-occurance of any such outcome with this type of a system.

2.1.4 Testing and Implementation

Before conclusions can be drawn from the results of the model, it is necessary to prove that the model is functioning correctly and to what degree the model represents the real system. This requires the model to be verified (this ensures that the model is mathematically sound and functioning as it was designed to) and validated (comparing of the model's outcome with that of reality to check the validity of the model).

Ultimately the model outcome should be compared with that of reality to test the alternatives indicated by the model. However, at times it may not be possible to validate a model because: 1) the new system may not yet exist, or 2) there may be too little quantitative information available about the real system to be used as a basis for the comparison.

Should either of these events exist, then the decision to accept the model must incorporate the element of subjective judgement to balance the objectives of the study against the realism and complexity of the model (Wright, 1970).

2.1.5 Application of Systems Research

The systems approach technique in conjunction with the computer has become an important aid in making economic decisions within the farming sector, for it is a fast and effective method to evaluate a number of alternatives to a given situation. And since the systems models are based on real world observations, the circumstance in which the system must operate can be adjusted to determine the "best" or optimum alternative for that particular situation.

In any managerial decision making process, optimum management occurs when the economic performance of the complete system has been maximized. For example, in the area of farm management, one of the important optimization areas is the area of machinery management. Machinery costs are one of the few variables that good management can influence, thus it is vital to the success of the farming system that the farm manager knows how to:

1) Evaluate machine performance
2) Estimate machine cost
3) Select machine systems.

Based on this philosophy, machinery selection models have been developed to assist in maximizing the economic performance of the machinery set. These models are often based on a least cost method.

Singh (1978) developed a computer model to design field machinery systems for multi-crop farms. The model designed the machinery set based upon field work specifications, field operation calendar date constraints, machinery capacity relations, and field work conditions. It specified the size and number of each machinery component, prepared a weekly schedule of field operations and labor requirements, and calculated a complete cost analysis of the machinery set selected.

Wolak (1981) utilized a deterministic model which uses standard engineering techniques to match machine productivity to the time available to complete the sequence of operations. The smallest machinery compliment which produced a satisfactory work schedule was selected as the required machinery set. The machinery sets are ranked on a per hectare basis and the average annual costs (depreciation, interest, repairs, shelter, insurance, and fuel cost) for each machine were determined.

Muhtar (1982) developed a machinery selection model to analyze machinery requirements for different tillage systems. The model was used to determine the optimum size machinery for conservation and conventional tillage based upon performance and economic criteria. The results for the different crop sequence on different farm sizes showed that conservation tillage could provide a lower cost in producing the same crop sequence.

Burrows and Siemens (1974) developed a computer model to determine the least cost, number and size of machines for corn-soybean farmers in the corn belt. The model was designed as an educational tool for assisting farmers with their machinery purchasing decisions. The model selected the machinery set resulting in the minimum total cost, and listed the schedule of field operations, annual machine use and itemized the machine costs.

Frisby and Bockhop (1968) developed a model to select a machinery system based on effective field capacity and annual cost of ownership. The model determined the acreage yielding maximum income for a given system and to decide when the system should be abandoned as acreage increased. They found that it is possible to determine the acreage, based on harvest-completion probability which yields maximum income and to revise the machinery system to increase the limiting acreage based on the fall plowing completion probability to that required for maximum income.

Agricultural economists have utilized the systems research technique as a means to better estimate the machine ownership costs due to inflation and changes in the federal tax policies.

Rotz and Black (1981) developed a cash flow model for cost analysis of agricultural machinery which includes the effects of inflation. Their model provides similar results as the traditional fixed-variable cost method, but provides better results when comparing a capital-intense machine or system with low operating costs to a less capital-intense alternative with higher operating costs.

Smith and Oliver (1974) developed a model using an annuity method for evaluating farm machinery costs. The annuity approach breaks the initial investment of the machine down to a series of equal annual costs. They compared the popular straight-line depreciation and found that their annuity approach accurately described the annual costs that the owner actually occurs with large investments and high interest rates.

Bloome, Nelson, and Roush (1975) modeled a cash flow and present value analysis method for farm investments. Comparisons were made with the fixed-variable cost analysis method. They found that their cash flow analysis provided a clearer view of financing and income tax effects on machinery costs.

2.2 Previous Strawberry Studies

Growers need economic guidelines for estimating the prospective cost and income to their enterprise. With this information growers can better evaluate their farm situation and can make better decisions regarding the potential returns and establishment costs. Cost evaluation information of this type has been developed by Kelsey and Johnson (1979) and Kelsey and Belter (1974).

Kelsey and Belter (1974) outlined a method of analyzing strawberry production costs in southwestern Michigan. The information was organized to assist the growers in estimating their production costs and a projected income. The budgeting information was organized so that the individual growers could adjust the information to be more representative to their farming situation. This information is useful to the grower as a basis for future decision making. Kelsey and Johnson (1979) updated the budgeting information and tables developed by Kelsey and Belter (1974).

Hussen (1979) reported the efforts to mechanize the strawberry harvest in Oregon. He examined the conditions and circumstances in which mechanical harvesting of strawberries would be economically feasible. Assumptions about the machine's cost and performance were based on actual observations as well as potential performance of the 1977 Canners Machinery Limited (CML) strawberry harvester which was operated in Oregon on an experimental basis. Depending on the assumptions regarding the yield and quality of the strawberries, and the efficiency of the harvester, Hussen estimated the net savings to the grower for mechanically harvested strawberries to range from $523 to a net loss of $187 per acre. Even though net losses were possible under unfavorable condiditions, in most cases positive returns to the grower were estimated from mechanical harvesting of strawberries.

Kim et al. (1979) compared production costs and net revenues for hand-picked versus mechanically harvested strawberries. Net revenues were computed on the assumption of no difficulty in procuring labor for hand picking. Results indicated that in some cases mechanical harvesting may be profitable to growers, providing harvesting occurred on the appropriate dates. Even with relatively lower strawberry prices, mechanical harvesting was more favorable than hand harvesting.

Holtman et al. (1977) tested a complete system for mechanical harvesting and processing of strawberries. The test results were used to analyze the economic viability of the system. Some of the results were promising but it was apparent that changes in the cultural practices and harvesting system would be needed if the new system was to be competitive with the conventional hand-pick system.

Fridley and Adrian (1968) described a method for studying the economic feasibility of developing a mechanical harvesting system. A set of nomograms was developed to assist in analyzing the feasibility of a system. The factors indicating feasibility were evaluated for several crops using typical economic values for hand harvest. The economic soundness of a mechanical harvesting system depends upon the amount of fruit lost (unrecovered) in excess of normal hand harvest loss, degree of mechanization, and rate of harvest. The nomograms can be used for modifying the assumptions of fruit loss, equipment cost, equipment use, and crew size. They can also be used to evaluate the effect of having a multiple row harvester as well as evaluating a complete harvest system.

2.3 Summary

Systems research is a technique which incorporates the benefits of the computer to thoroughly examine a complete system in an effort to pinpoint the problem areas within that system, with the intentions of redesigning the system or adjusting the system components to create a more efficient and profitable system. Agricultural engineers and researchers have successfully employed the systems research technique and have proven it to be a useful tool for selecting and evaluating agricultural systems.

CHAPTER III

CURRENT SOLID-SET PRODUCTION PRACTICES AND CULTURE OPERATIONS

3.1 Introduction

Mechanical harvesting of strawberries is an interdisciplinary problem; a problem which requires the combined efforts of engineers, growers, horticulturalists, plant breeders, and food technologists.

Since the strawberry plant is a low growing plant the cultural practices had to be modified to better facilitate the needs of the harvester. The solid-set cultural technique as modified by the Michigan growers has provided the cultural changes needed by the harvester and at the same time other favorable attributes were achieved such as increased crop yields and uniform ripening of the fruit clusters.

Michigan's concept of solid-set culture is based on Dr. C. L. Ricketson's research at the Horticultural Research Institute of Ontario, Canada. In solid-set culture, the strawberry plants are not restricted or confined to rows but are permitted to develop runners to cover the entire field surface. With this technique, Ricketson was able to obtain inceased yields over that of the traditional row plantings (Ricketson, 1968). However, in order to establish and obtain the benefits of the solid-set culture, it requires approximatley a 40 to 50 percent increase in the stawberry plant density per acre at the time of transplanting. The benefits achieved from this technique are: 1) increased crop yields, 2) more uniform ripening of the fruit clusters, and 3) assists in the weed management program by limiting the soil surface and sunlight available for weed growth. The Michigan growers refined the system to grow the berries on a smoother field surface. This is accomplished by rolling the fields in the spring of the year to smooth the field surface and when needed, prior to transplanting, leveling the field with a land plane. The solid-set production costs due to the increased plant density and rolling of the fields are off-set by the elimination of the traditional field operations of field cultivation, mulching, mowing and rototilling.

3.2 Description of Current Cultural Practices

The following information is a summary of various articles written by James Grant (1980, 1982), Richard Ledebuhr (1982), and Clarence Hansen (1983). This section describes Michigan's current cultural practices for raising solid-set culture strawberries.

3.2.1 Site Selection

A preferred site consists of a uniform topography on a well-drained sandy loam soil. The topography characteristics need to be consistent to promote uniform ripening throughout the field. It is important to select a level field with a sunny site. A slope of 2 to 3 percent is ideal. This slope will allow excess water to runoff, yet is mild enough to prevent soil erosion. Fields with hills and dips should be avoided, for the berries on the hill crests will be overripe before the berries in the dips ripen.

3.2.2 Pre-Plant Soil Preparation

It is beneficial to begin the soil preparation at least one year prior to planting. This includes soil samples for determining fertilizer application rates and soil fumigation for nematode control. A soil building program of a green manure plow down crop prior to planting strawberries adds organic matter to the soil and helps to eliminate weeds and grubs. It is important that the soil is fertile and free of rocks, weeds, herbicide build up, and soil borne diseases. Any of these problems will reduce the new planting's ability to grow uniformly solid, which in turn will reduce the potential yield and harvester recovery efficiency.

Correct and proper field surface preparation and maintenance is vital for an efficient harvest recovery. The field surface needs to be smooth and free of irregularities such as soil washes and stones. For severe soil surface irregularities, a land plane is effective for smoothing and grading the soil surface.

3.2.3 Planting - Spring First Year

If a perennial cover crop is used, one which is resistant to winter kill, then a contact herbicide is used to eliminate the fall cover crop. For in this technology, the strawberry plants are transplanted as a no tillage operation. Plants are set with a modified mechanical transplanter. The modification consists of a 50 cm (20 in) rippled coulter which is mounted in front of the furrow opener. The coulter cuts through the roots of the cover crop allowing the furrow opener to penetrate the untilled soil with a minimum of soil disturbance. Planting is followed by a cultipacker to level the field and to firm the plants in the soil.

Immediately after cultipacking, the field is irrigated. Irrigation is necessary in establishing the new plant growth, since each plant has to produce a number of daughter plants if the field is to be solidly covered by fall.

3.2.4 Post - Plant Care, First Year

Herbicides, insecticides and fertilizer are applied as needed. Hand hoeing and weed pulling are necessary until the new crop has adequately filled in enough to shade out future weed development. The strawberry plant leaf canopy along with the application of herbicides, controls the weeds sufficiently to make hand hoeing of those remaining practical.

In solid-set culture, a cultivator is not used to control weeds. Cultivation causes ridges and prevents a solid uniform field coverage of new runner plants. These new runner plants (daughter plants) increase the field plant population. The canopy of these new strawberry plant leaves inhibits new weed growth and provides a natural mulch to minimize the cold damage during the winter season.

3.2.5 Post - Plant Care, Spring of Harvest Year

In the spring, plants are given their final preparation for harvest. This consists of rolling the fields, and applying fertilizers and herbicides. These operations must be completed while the plants are still dormant.

Rolling is one of the most important operations in this cultural system of growing strawberries. Rolling pushes the frost heaved crowns and stones back into the soil without causing damage to the crowns, providing it is done while the soil is still moist and plastic. Rolling improves the harvester recovery by allowing the cutter bar to be accurately positioned to the soil surface without concern of jamming the cutter bar with crown tops or stones. The operating zone for the cutter bar is 1.3 to 1.6 cm (1/2 to 5/8 in) above the soil surface.

Rolling is accomplished by pulling two, 50 cm (20 in) diameter pipes 2.1 m (7.0 ft) long behind a light tractor. The pipes are filled with water and pulled in tandom, so that the plantings are rolled twice by each pass across the field. Generally one pass is sufficient providing the field was properly groomed the previous year.

Hand hoeing and weed pulling are necessary until the strawberry plant canopy has adequately filled in to prevent future weed development. This is a priority activity for it must be completed before the plants form fruit buds. Once the fruit buds are formed, no other foot activity is permitted within the field.

A well-planned fertilizer program is necessary to obtain plant heights of 30 to 45 cm (12 to 18 in) at harvest time. Fertilizer and fungicides have been successfully applied through the irrigation systems. Insecticides and fungicides have also been applied by an airblast sprayer traveling in sprayer lanes spaced at 18 meters (59 ft) apart or by aircraft.

3.2.6 Post - Harvest Cultural Practices

For the past three years the plant leaves and debris have been raked from the field after harvest by a side delivery hay rake. Originally, raking was thought to be beneficial in the removal of a habitat for pathogens. However, during the 1983 season some of the foilage was left in the field to shade the crowns from the sun, thus allowing for a more vigorous regrowth. With this in mind, a method of shredding the foilage as it is discharged from the harvester should be considered.

Regardless of the method of handling the leaves from the harvester, it is important to irrigate the strawberry crowns immediately after the harvest operation. The crowns need to be irrigated frequently to promote regrowth. Approximately one week after harvest, fertilizer and herbicides are applied and irrigation is continued until cooler weather arrives. Hand weeding may be necessary during this period.

At the present time growers and researchers do not know the number of years these field can be machine harvested. So far the fields have been machine harvested for four years and the fields are still in very good condition.

3.3 Advantages of Solid-Set Culture

Solid-set culture has contributed some very positive factors to the present success of mechanical harvesting (Ledebuhr, 1982). The benefits of this cultural technique are: 1) increased crop yields, 2) more uniform ripening of berry clusters, and 3) high harvester field recovery.

An increase in the crop yield allows for a greater potential return per hectare. Since harvest costs are a fixed cost per hectare for a given size farm, a high yielding crop reduces the cost of mechanical harvesting per kilogram of berries.

The strawberry plants grown in this technique have no exposed edges, consequently the berry clusters are uniformly shaded and suspended within the plant canopy by the surrounding foilage. This shaded plant canopy tends to delay ripening of the primary flower thus allowing the secondary and tertiary berries to develop and ripen more uniformly. The more uniform ripening of the berry clusters allows for a maximum quantity of usable fruit and less loss due to green non-ripe or to overripe and decayed berries.

The higher field recovery results from the increased field plant foilage which supports the fruit clusters within the plant canopy and the smooth field surface which enables the cutter bar of the harvester to be accurately positioned relative to the soil surface for a higher field recovery. The increase in foilage height decreases the soil borne fruit decay by supporting the clusters up within the canopy and off the soil surface. This also facilitates harvesting by allowing the cutter bar to slide under the berry clusters before it severs the plant vine from the soil surface.

3.4 Strawberry Plant Variety

The strawberry plant variety must ripen uniformly without being overripe, yield well, and possess a berry with a convex berry calyx with a pedicel length of 4-6 cm. The berry shape and cluster length are important for machine harvesting, handling, and processing. The berry and cluster characteristics complement the working efficiencies of the machine processing system. The berry stems must be long enough on the cluster so the berry and berry stem can be separated from the cluster node (Figure 3-1). A minimum berry stem length of 2.5 cm (1 in) is necessary for the Michigan State University-Canners Machinery Limited (MSU-CML) decapper used at the processing plant. The berry stem must be firmly attached to the berry so that the stem does not easily pull or separate from the berry as it is picked up by the MSU-CML decapper. At the present time there is only one strawberry plant variety, the variety 'Midway' which possesses the necessary traits needed for this processing technology. However, should the grower-processor choose to process the complete raw fruit product as 100 percent puree, then the shape of the berry calyx, cluster length, and the strength of the berry attachment to the stem is not as important.

Plant breeders need to develop more varieties which possess the necesary traits for mechanical harvesting and processing which are capable of growing in the same area with concentrated ripening at different times during the harvest season. This would extend the harvesting season, therefore allowing the grower to increase the size of their enterprise thus reducing the machine's fixed cost per hectare.

3.5 Plant Density Study

As part of this research, a study was conducted to examine the effects of transplant spacing upon the number of viable plants (mother and daughter) present at harvest time. The objective was to determine if one of the plant spacings provided a better establishment of new crowns than another. Three plant spacings were available for this comparison. These plant spacings were: 1) 91 x 61 cm (36 x 24 in), 2) 61 x 61 cm (24 x 24 in) and 3) 46 x 61 cm (18 x 24 in).

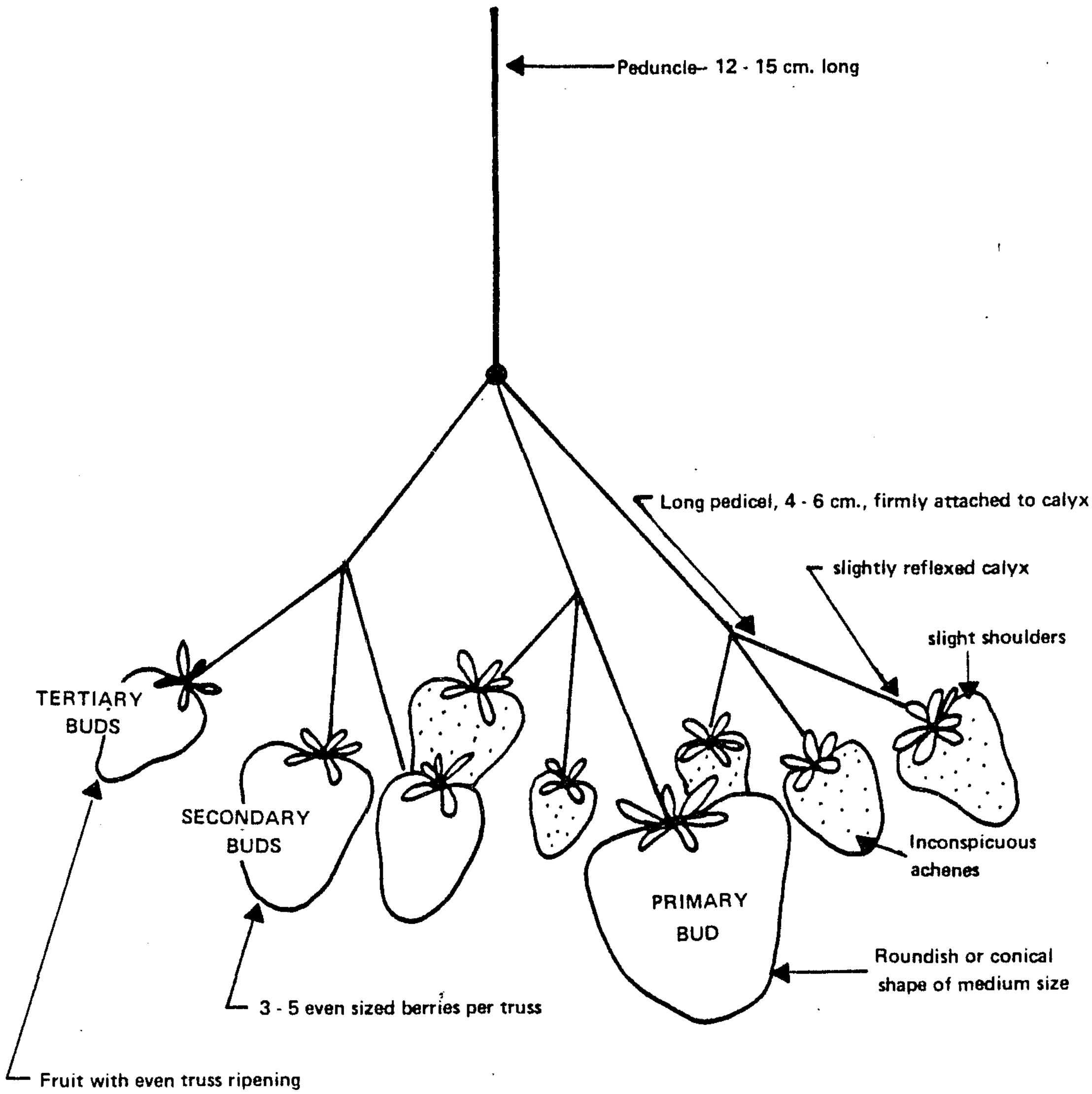


Figure 3-1. Idealized Strawberry Truss for Mechanical Harvesting

3.5.1 Method of Data Collection

At harvest time a 0.19 square meter (2.0 square feet) frame was randomly placed in the field. All of the strawberry plants within the frame were counted and recorded (Appendix 1). This procedure was used for all three plant spacings as the method of data collection.

A total of 104 plant crown density samples were recorded. The number of samples in each of the three plant spacings varied due to the size of the test plot and to the time available for the sample collection. Forty-eight samples were recorded in the 91 x 61 cm spacing, 44 samples in the 61 x 61 cm spacing, and 12 samples in the 46 x 61 cm spacing.

3.5.2 Analysis

Analysis of data was done by using the Minitab Statistical Package on the Michigan State University's Control Data Corporation Cyber 750 Computer.

The null hypothesis tested using the one way analysis of variance technique (Minitab, Subprogram AOVONEWAY) was:

H_0:

There are no significant differences in the number of strawberry plants per unit area among the three plant spacing densities.

This hypothesis was rejected at the .05 level (95% C.I.). Significant difference was found among the three plant spacings. The F-test showed a significant difference among the plant spacings (densities) at the 95 percent level. Examination of the confidence interval indicated that C1 and C3 (plant spacing of 91 x 61 cm and 46 x 61 cm) do not differ appreciably but that the mean plant density of C2 (plant spacing of 61 x 61 cm) is considerably greater than the means of C1 and C3 (Table 3-1). Consequently, C2 provides a greater plant density than either of the other two transplant spacings and at less cost than that of C3 which is the high density transplant spacing.

Table 3-1. One Way Analysis of Variance Output from the Minitab Subprogram AOVONEWAY.

```
C1= COLUMN 1 DATA= PLANT SPACING OF 91 X 61 CM (36 x 24 IN.)
C2= COLUMN 2 DATA= PLANT SPACING OF 61 X 61 CM (24 X 24 IN.)
C3= COLUMN 3 DATA= PLANT SPACING OF 46 X 61 CM (18 X 24 IN.)
```

```
ANALYSIS OF VARIANCE

DUE TO          DF          SS     MS=SS/DF      F-RATIO
FACTOR           2      1451.1        725.5        28.20
ERROR          101      2598.9         25.7
TOTAL          103      4050.0

LEVEL          N          MEAN         ST. DEV.
C1            48         18.85            5.33
C2            44         25.75            5.24
C3            12         16.33            2.74

POOLED ST. DEV. =          5.07

INDIVIDUAL 95 PERCENT C. I. FOR LEVEL MEANS
(BASED ON POOLED STANDARD DEVIATION)
       ---------+---------+---------+---------+---------+---------+
C1                     I****I****I
C2                                               I****I****I
C3          I********I*********I
       ---------+---------+---------+---------+---------+---------+
     12.0      15.0      18.0      21.0      24.0      27.0      30.0
```

3.6 Summary

The solid-set strawberry production technique has contributed greatly to the present success of the mechanical harvester. This cultural technique provides for an increased crop yield and a more uniform ripening of the fruit clusters. The Michigan growers refined the field production system to accommodate the cutting and pickup mechanism of the harvester by growing the crop on a smooth field surface.

The results of the preliminary transplant density study shows that there is an optimum transplant density to achieve a maximum number of viable strawberry plants (mother and daughter) at the time of harvest. The results of this preliminary study shows that there is a need for further research in this area to determine the optimum transplant density which will provide the grower with the largest quantity of viable plants at harvest with the least initial investment.

CHAPTER IV

CURRENT STATE OF THE ART HARVESTER

4.1 Harvester Description

The 1983 harvester model was built by Robert Buskirk of Paw Paw, Michigan and included the earlier harvester concepts developed by Michigan State University agricultural engineers and others. The more technically complex machine components of the harvester were designed and fabricated at Michigan State University and Canners Machinery Limited (CML) of Ontario, Canada (Hansen, 1983).

The harvester was built on a 4-wheel drive truck chasis and is propelled by hydraulic motors. The harvester is powered by a 75 kW (100 hp) engine which drives hydraulic pumps and a line shaft for mechanical drive to the fans (Figure 4-1).

The 122 cm (48 in) long cutter bar is of a double sickle design with sections on 3.8 cm (1.5 in) centers. Each sickle is driven through a bell crank by a cam follower in an eccentric groove of a fly wheel powered by a hydraulic motor. An 8-bar pick-up reel assists in moving and lifting the crop over the cutter bar. Crop lifters are fitted below the cutter bar which allow the plants to be cut close to the crown and to assist in lifting the crop onto the first draper. The entire cutter head including the first conveyor is designed to "float" on the ground to insure uniform cutting of the crop.

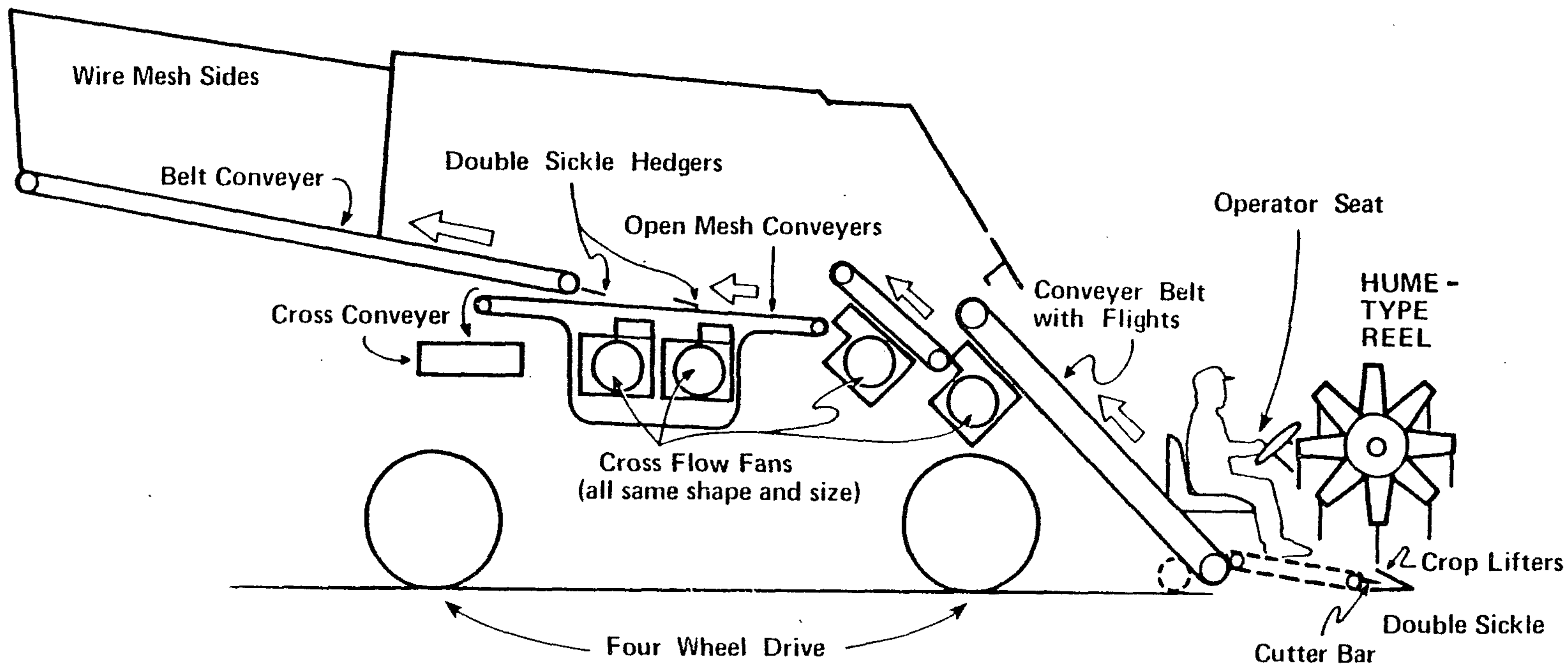


Figure 4-1. Schematic of the Harvester

The first conveyor lifts the crop onto a flighted conveyor which elevates the fruit and foilage into the separating chamber of the harvester. The separating chamber consists of a third inclined conveyor and two specially designed cross flow fans, each fan providing a velocity of 1800 meters per minute (5,900 ft per minute). The two front fans are located below the inclined conveyors (one fan per conveyor) directing their air streams parallel with the undersides of the conveyors and towards the rear of the harvester.

As the crop falls from the second conveyor to the third conveyor and from the third conveyor to the open grid conveyor, the fruit passes through the two air streams created by the fans. The lighter material, being mostly plant foilage is blown free from the fruit and to the rear of the harvester where it lands on a belt conveyor and discharged from the harvester.

The fruit, being heavier than the plant foilage, gently falls from the third conveyor onto the open grid conveyor. The grid conveyor is made from 0.635 cm (0.25) round rods attached to 1.58 cm (0.62 in) roller chain. The upward air streams created by the two cross flow fans located below the open grid conveyor serves three purposes, first it eases the fruits fall to the grid conveyor, second it orients the berry cluster vertically as they pass through the two sets of hedges which singulate the fruit leaving 2-3 cm (3/4 to 1 in) stem, and third the air streams continue the process of removing the leaves, stems and other debris.

A cross conveyor at the rear of the harvester receives the fruit from the grid conveyor and carries the fruit to the workers platform where the fruit is placed in boxes. During the 1983 season the fruit was caught in plastic stackable boxes which hold approximately 14 kilograms (30 lbs). The stackable boxes were placed on pallets and lowered to the ground preferably at the end of the field. This reduces the wheel traffic on the plant crowns within the field. The fruit filled pallets were loaded on trucks and transported to the processing plant.

For the 1984 season this harvester will be equipped with pallet boxes in place of the plastic stackable boxes. The pallet boxes measure 100 x 100 x 75 cm (40 x 40 x 30 in) and hold approximately 136 kg (300 lbs). When filled, the pallet boxes will be rolled from the loading platform on a roller conveyor to the ground. This system of bulk handling has been successfully used by two Michigan growers.

4.2 Harvester Recovery Rate

As part of this research, a study was conducted to determine the recovery rate of the harvester. This recovery rate was taken for all the berries present at harvest time. This includes primary, secondary, and tertiary berries.

4.2.1 Method of Data Collection

The recovery rate of the harvester and crop-related factors which affect the recovery rate of the harvester were obtained by random field samples. These samples were taken in pairs, one before and one after the harvester. The first sample, sample A was taken before harvesting. Three items of information were collected at this sample: 1) All of the berries within a 0.19 m2 (2.0 ft2) square frame were hand picked. 2) A plant density count within the frame was taken. 3) The foilage height at this location was recorded. The second sample, sample B was made in the same general location after the harvester had passed. Sample B included two items of information: 1) the collection of all berries and berry flesh missed by the harvester within the 0.19 m^2 (2.0 ft^2) square frame and, 2) a second plant (crown) density count was taken at this location.

A total of 31 paired samples were collected within the five day harvest period. The berries in both samples (A and B) were sorted by color, weighed, and recorded by calendar date. The fruit was color classified by visual inspection and placed in one of three categories: 1) non-ripe, 2) ripe and, 3) overripe. The fruit in the non-ripe category consisted of the immature berries which were identified by exhibiting one of the following colors; green, white or pink. The ripe berry category consisted of only the fruit which were 100 percent red in color whereas the berries in the overripe category exhibited visual signs of fruit decay. The percent recovery was recorded for each color category (Appendix 2).

4.2.2 Results

The 1983 results indicate that the field recovery efficiency for the harvester described in Section 4.1 ranged from 59 to 95 percent of all available berries (non-ripe, ripe, and overripe). The season's recovery average for all berries was 87 percent. The recovery of red ripe fruit was greater than that of all (total) berry recovery. Red ripe fruit recovery ranged from 81 to 99 percent with the season's average being 93 percent.

The lower recovery rate in the all berry category is due to the light weight of the green non-ripe berry. The average mass of a small green non-ripe berry is 0.5 gram, whereas the average mass of the red ripe berry is 8 grams. Since the small green non-ripe berry mass is less than that of most plant foilage pieces, the small green berry is expelled from the harvester along with the plant foilage.

In the case of the sample with the recovery rate of 59 percent, field data records show that this sample averaged 221 grams of total berries less than the other samples recorded for that day. This indicates a greater quantity of green non-ripe fruit. Further investigation of the field data records shows that 39 percent of the fruit in this sample was classified as green non-ripe with an average mass of 0.3 gram per green berry. Therefore, with this lighter mass per berry more of this sample's green non-ripe fruit was expelled from the harvester with the plant foilage.

The extremely overripe berries tend to shatter from their stems and fall to the ground as the pick-up reel of the harvester enters the crop foilage. The field loss of these berries due to their degree of overripeness is of no harvest value to the grower for they would only be sorted out and discarded at the processing plant.

4.3 Factors Affecting the Harvester Recovery Rate

The field recovery rates of the harvester are affected by a combination of factors. These factors are: 1) operator skills, 2) field surface conditions, and 3) crop conditions.

The skill of the operator is important in making and maintaining the necessary machine adjustments so that the machine is compatible with the field and crop conditions. The field surface when properly prepared is free of soil surface irregularities. This enables the operator to accurately position the cutter bar relative to the soil surface.

Data from Appendix 2 implies recovery rates to increase as crop density per unit area and foilage height increase. The density of the crop and the height of the foilage assists recovery by suspending and supporting the berry clusters in the foilage.

To test the effect of plant density and foilage height on the percent recovery by the mechanical harvester a stepwise regression analysis was performed on the data in Appendix 2, Table A2. This analysis was completed by using the SPSS Statistical Package on the Michigan State University's Control Data Corporation Cyber 750 Computer.

H_0:

Plant density and plant foilage height do not have an effect upon the fruit recovery rate by the mechanical harvester.

The F-test of the model for the two variables FOLHGT and CRNDSTY when tested independently at the .05 confidence level, both reflected to have a non-significant prediction for the fruit recovery rate by the harvester. In other words, the fruit recovery rate by the harvester was not significantly correlated soley to either FOLHGT or CRNDSTY.

$$F_{FOLHGT} = 2.734 < F_{0.05} = 4.28$$

$$F_{CRNDSTY} = 2.472 < F_{0.05} = 4.28$$

However, a stepwise regression analysis of the model which included both variables simultaneously was significant and reflected a higher coefficient of correlation. As a result, a model utilizing the two independent variables FOLHGT and CRNDSTY would more accurately explain the change in the dependent variable PCRALL. Moreover, the R^2 change value shows that the percent of explanation by the plant foilage height to be greater than that of the plant density (Table 4-1).

$R^2_{FOLHGT + CRNDSTY}=0.151 > r^2_{FOLHGT}=0.106 > r^2_{CRNDSTY}=0.097$

Appendix 3 graphically illustrates the statistical results of the plant foilage height and plant density.

4.4 Field Capacity

In 1983, the season's average effective field capacity (EFC) of the harvester was 0.12 hectare per hour (0.30 acre per hour). EFC is the actual rate of harvester performance, expressed in hectares per hour (acres per hour) [Appendix 4].

The theoretical field capacity (TFC) of the harvester was calculated to be 0.24 hectare per hour (0.60 acre per hour). TFC is the rate of field coverage that would be obtained by the harvester if it were performing its function 100 percent of the time at the rated operating speed and always utilized 100 percent of its rated cutter bar width. This maximum capacity is used as a basis for evaluating the performance of the harvester and its operator. TFC is calculated by multiplying the harvesting speed by the rated cutter bar width and dividing by a constant of 10 (8.25). This constant of 10 (8.25) enables the calculation to be expressed in hectares per hour (acres per hour).

$$TFC = \frac{\text{speed} \times \text{width}}{\text{constant}}$$

The average field efficiency (FE) of the harvester for this season was 50 percent. However, next year with a bulk handling system for the

Table 4-1. Multiple Regression Analysis Summary Table on the Variables Foilage Height and Crown Density.

* * * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * *

DEPENDENT VARIABLE..   PCRALL   PERCENT RECOVERY FOR ALL BERRY

S U M M A R Y   T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	CRNDSTY		2.47200	.130	.31153	.09705	.09705	-.31153	2.47200	.130

* * * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * *

DEPENDENT VARIABLE..   PCRALL   PERCENT RECOVERY FOR ALL BERRY

S U M M A R Y   T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	FOLHGT		2.73375	.112	.32593	.10623	.10623	-.32593	2.73375	.112

* * * * * * * * * * * * M U L T I P L E   R E G R E S S I O N * * * * * * * * * * * *

DEPENDENT VARIABLE..   PCRALL   PERCENT RECOVERY FOR ALL BERRY

S U M M A R Y   T A B L E

STEP	VARIABLE ENTERED	VARIABLE REMOVED	F TO ENTER OR REMOVE	SIGNIFICANCE	MULTIPLE R	R SQUARE	R SQUARE CHANGE	SIMPLE R	OVERALL F	SIGNIFICANCE
1	FOLHGT		2.73375	.112	.32593	.10623	.10623	-.32593	2.73375	.112
2	CRNDSTY		4.46714	.046	.50703	.25708	.15085	-.31153	3.80649	.038

harvested fruit, the FE is expected to increase to approximately 80 percent. Field efficiency is the ratio of the harvester's EFC to its TFC. Field efficiency is calculated by dividing the harvester's EFC by its TFC and expressed as a percent.

$$FE = \frac{EFC}{TFC} \times 100$$

Once the operator can identify the production system's inefficiencies and correct for them, then the field efficiency and field capacity of the harvester can be increased. The factors which affect the harvester's field efficiency and field capacity are:

1) Skill and experience of the operator.
2) Crop and field conditions.
3) Proper operating speeds and adjustments of harvester components.
4) Ground speed of the machine.
5) Actual width of the header used.
6) Material handling system's capacity.

4.5 Summary

The mechanical harvester can alleviate the labor shortage dilemma which frequently confronts the grower during the harvest season. The mechanical harvester in conjunction with the proper cultural practices has been proven to successfully harvest the fruit with an average fruit recovery rate of approximately 93 percent.

The mechanical harvester is one of the subsystems contributing to the total systems approach for the mechanization of the strawberry industry. After the fruit is harvested it is transported to the processing plant where the fruit is mechanically handled and processed into its final product.

CHAPTER V

CURRENT PROCESSING EQUIPMENT AND OPERATIONS

5.1 Introduction

Handling mechanically harvested fruit in the processing plant is only a part of the total systems approach to mechanize the strawberry industry. In other words, the success of the crop production and mechanical harvesting system is dependent upon the ability of the processing plant to handle the mechanically harvested fruit. Therefore, the final step in mechanizing the industry was to develop processing equipment which is capable of handling machine harvested fruit. Each machine at the processing plant has a vital role in the completion of the final fruit product. However, if any one machine in the processing plant was to be considered the "key machine" in the success of handling machine harvested fruit, it would be the decapper. Hansen, (1972) stated:

> "It is quite apparent that if we are to lift the sagging strawberry industry in Michigan it will be necessary to concentrate efforts on a machine to remove the caps".

At the present time, a mechanical decapper has been developed which successfully completes this operation. The efficiency of the decapper as well as the other processing equipment are discussed within this chapter.

5.1.1 Processing Equipment and Operations

Figure 5-1 shows a flow diagram of the 1983 strawberry processing line at Underwood's Farm Market in Traverse City, Michigan. This processing plant utilized the current Michigan State University-Canners Machinery Limited (MSU-CML) strawberry processing equipment. The fruit product at this processing center was processed as freezer pack and puree.

5.2 Description of the Processing Procedures

At the processing plant, the fruit is dumped into a receiving tank filled with water. This tank prewashes the fruit by allowing the sand and grit to settle out before the fruit enters the processing equipment. A six bar reel meters the fruit to a flighted conveyor which elevates the fruit to the receiving pan of the singulator.

The singulator separates the berry clusters into individual berries with stems (Figure 5-2). The singulator consists of three staggered layers of small diameter rods with 6.35 cm (2-1/2 in.) clearance between each rod and set at a downward angle of 20 degrees. The single (singulated) fruit falls between the rods and the fruit clusters slide down the rods to the shear bar which cuts the berry stems from the cluster node. The catch pan below the singulator directs the fruit onto the decapper.

The MSU-CML decapper consists of rubber covered counter-rotating rollers that travel up an incline (Figure 5-3). The berry stems are caught between the counter-rotating rollers and carried to a band knife where the usable fruit flesh is cut from the calyx and stem (Figure 5-4).

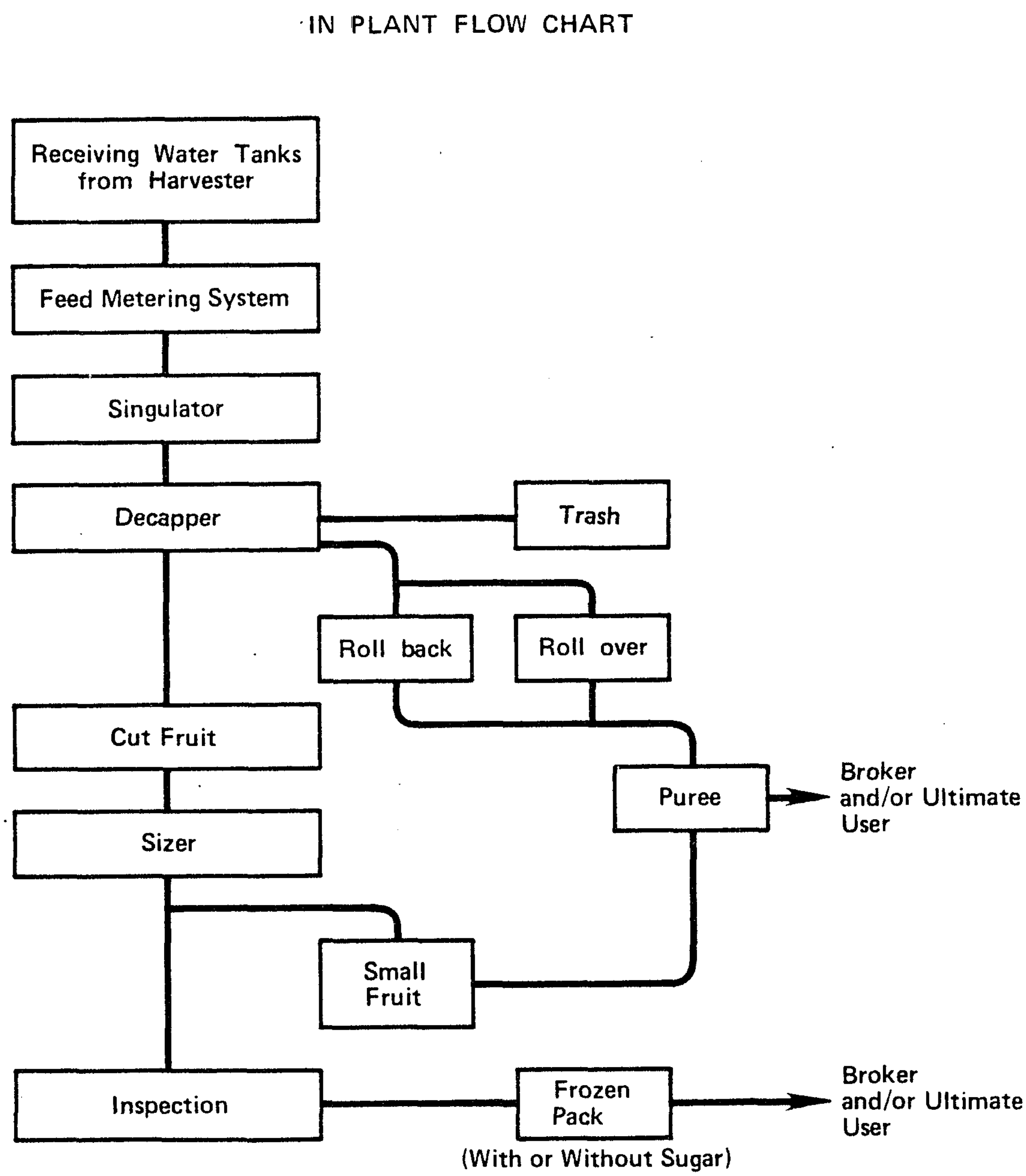


Figure 5-1. Processing Plant Flow Chart

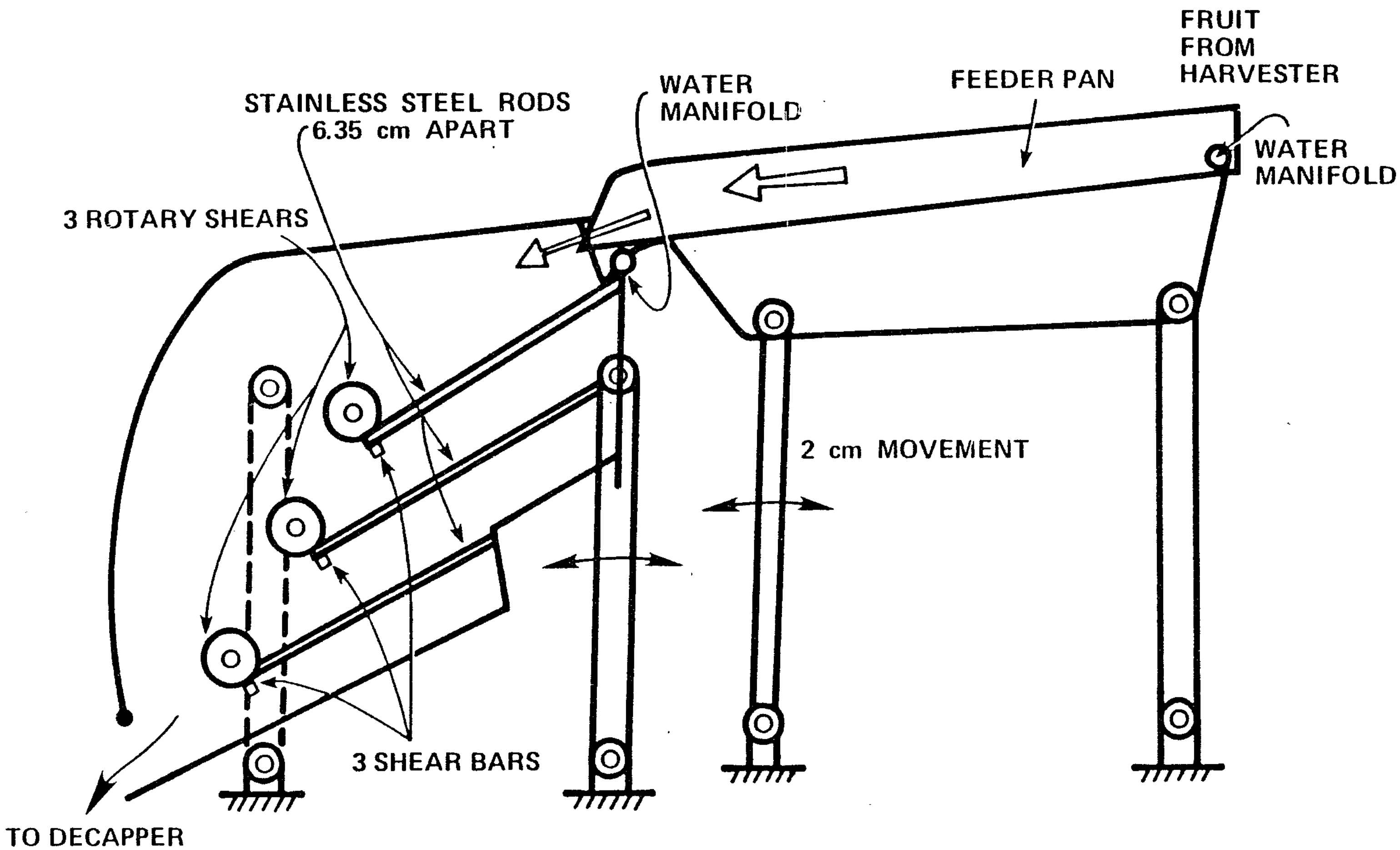


Figure 5-2. Schematic of the Seperator

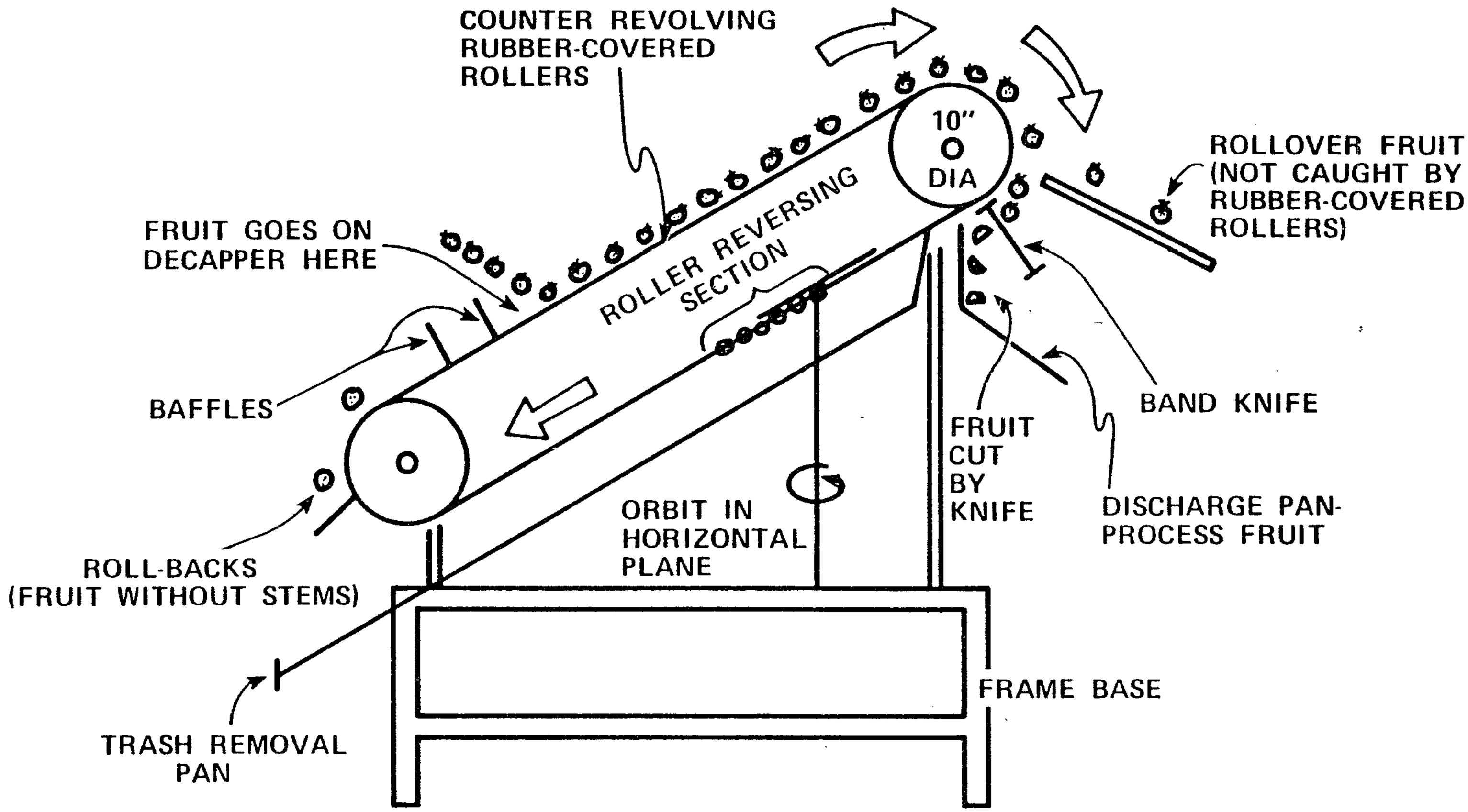


Figure 5-3. Schematic of the Decapper

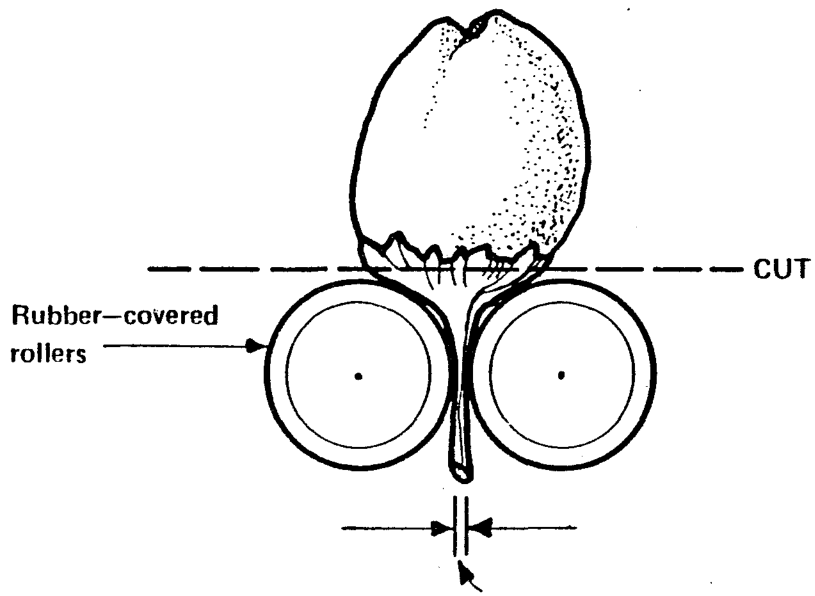


Figure 5-4. Schematic of the Fruit Showing Location of Cut

The entire inclined roller conveyor bed of the decapper orbits through a 2cm (0.75in) diameter circle in a horizontal plane to enhance the possibility for the rubber covered rollers to catch the stems of the fruit. The baffles which are located at the lower end of the inclined bed prevent the berries from rolling off the rear of the bed before the counter-rotating rollers have a chance to locate and secure the berry stems between the rollers so that the berries can be carried to the band knife. The band knife which is mounted below the upper end of the rubber covered roller conveyor, slices the usable fruit flesh from the stem and calyx. This cut fruit falls into a water flume and is carried to a sizer.

A reversing rack which changes the rotational direction of the rubber covered rollers is mounted below the return side of the roller conveyor. This rack reverses the rotation of the rubber covered rollers to discharge stems, leaves, calyxes, and any berry flesh which has been pulled through the rollers. This function permits a continuous operation of the roller belt. The debris is elevated into a bin for disposal.

The fruit is discharged from the decapper by one of three discharge points identified as: 1) cut fruit, 2) roll back, and 3) roll over. The cut fruit are the berries which were caught and held by the counter-rotating rubber covered rolls so that the calyxes (caps) could be removed by the band knife. This fruit is then conveyed to the sizer and inspection line before it is sliced and packaged. The fruit not caught by the counter-rotating rolls are identified as either roll-backs or roll-overs. Roll-backs are the berries which were encouraged by the orbiting motion of the decapper to roll back down off the inclined bed of the decapper. These berries have very short stems (less than 2.5 cm [1in]) or no stems at all. Roll-overs are the berries which were trapped or carried over the top of the inclined bed by other berries whose stems were firmly lodged between the rubber covered rollers. These berries can be either stemmed or stemless.

To avoid hand sorting and decapping of the roll-back and roll-over berries, the plant management may choose to puree these berries. If so, the berries from the roll-back and roll-over discharge points of the decapper are conveyed to an inspection table where the undesirable (decayed and rotten) berries are removed. The total product from this inspection belt including fruit stems are fed into a finisher which removes the leaves and stems.

The usable cut fruit (decapped fruit) is conveyed to the receiving pan of a tapered finger sizer (Figure 5-5). The receiving pan of the sizer is flooded with water and vibrates constantly to assist in moving the fruit down the tapered fingers. The small fruit, most of which are green non-ripe berries fall through the fingers first and are conveyed to the finisher for puree. The remaining fruit will eventually fall through or off the end of the fingers and onto the inspection belt. The hand sorters at the inspection belt sort out the less desirable fruit allowing only the ripe fruit to enter the slicer where it is sugared and placed into 14 kg (30 lb.) tins to be frozen.

5.3 Processing Equipment Evaluation

Data were collected at the processing plant for each machine to examine machine capacity and efficiency. Tables 5-1 and 5-2 show the 1983 average daily and season's values for the singulator and decapper.

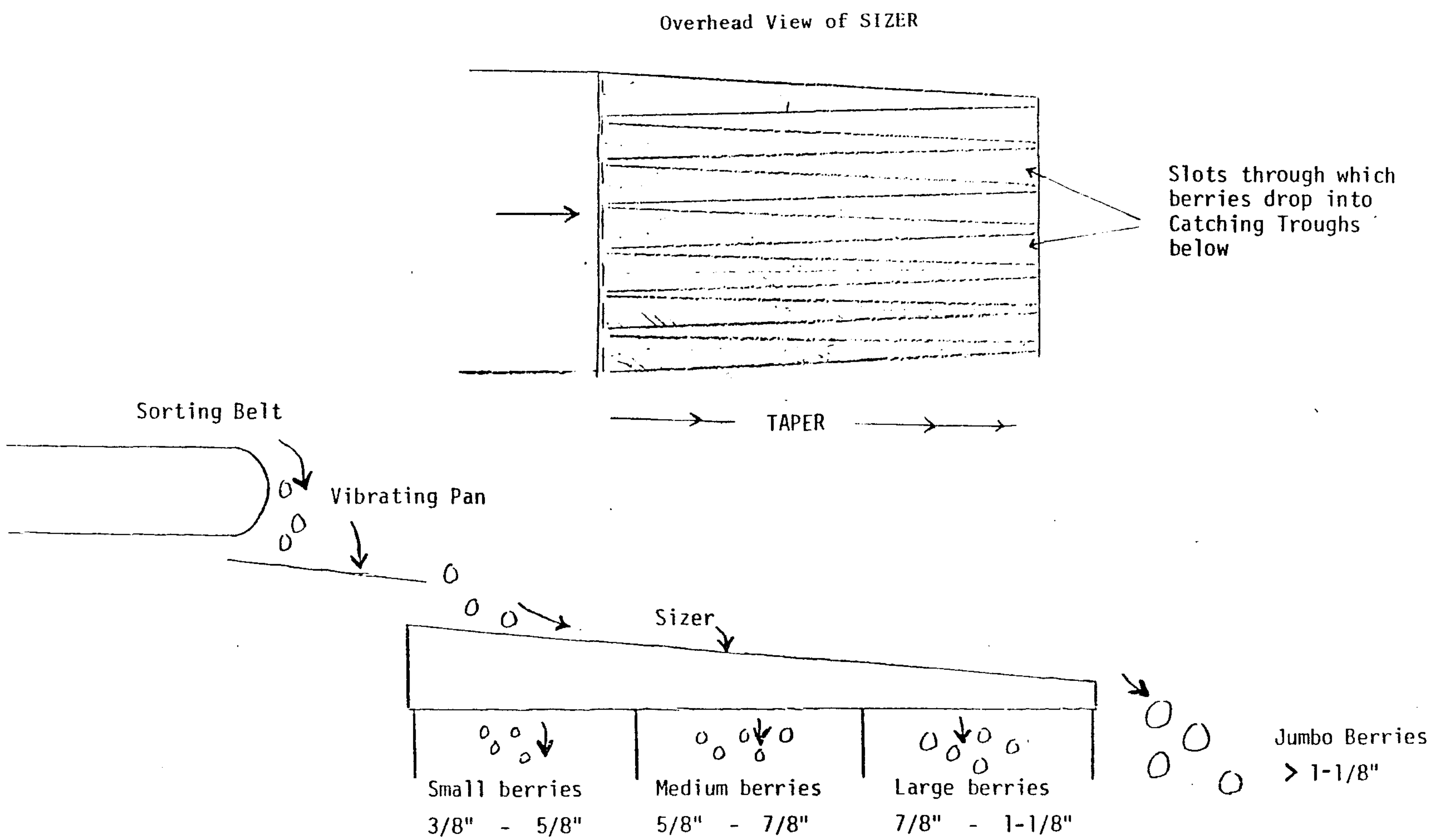


Figure 5-5. Schematic of the Sizer

Table 5-1. Singulator Evaluation

Daily Average 1983	Mass Kg	Weight lbs	Number Single Stems Before Singulator	Number Single Stems After Singulator	Percent Improvement	Before Singulator Number of Clusters	After Singulator Number of Clusters	Percent Improvement
July 3	1236	2725	12	28	57	12	4	67
4	2092	4613	27	40	32	6	2	67
5	2858	6300	24	39	38	7	2	71
6	3406	7509	21	36	42	6	3	50
7	2647	5835	47	44	-6.8	2	1	50
8	2290	5049	36	46	21	5	1	80
11	3096	6826	31	49	37	8	0	00
12	2021	4455	17	34	50	11	4	64
Season Average	2456	5414			33.5%			68.6%

Table 5-2. Decapper Evaluation

Mass and Percent at Discharge Points
Expressed on a Per Hour Basis

Daily Average 1983	Quantity to Decapper		Roll Back			Roll Over			Cut Fruit			Trash		
	Kg	Lbs	Kg	Lbs	%	Kg	Lbs	%	Kg	Lbs	%	Kg	Lbs	%
July 3	556	1225	141	311	25	82	181	15	206	453	37	127	281	23
July 4	1085	2393	231	509	21	212	467	20	393	866	36	250	551	23
July 5	1245	2745	289	636	23	258	568	21	470	1035	38	230	506	18
July 6	1283	2829	210	462	16	252	555	20	531	1170	41	291	642	23
July 7	1648	3634	283	623	17	374	825	23	677	1493	41	315	694	19
July 8	1179	2600	254	560	22	245	539	21	451	995	38	230	507	19
July 11	1470	3240	272	599	18	327	720	22	515	1134	35	357	788	25
July 12	1255	2768	276	608	22	194	428	15	378	833	30	408	900	33
Season Average	1215	2679			20			20			37			23

The singulator averaged 2456 kg per hour (5414 lbs/hr) for the season with a 38.3 percent improvement in the separation of single berries and a 68.6 percent improvement in the separation of clusters. In this study a cluster is defined as 3 or more berries connected at a node. For example, on July 3, 1983 prior to singulation, there were an average of 12 clusters per sample entering the singulator and after passing through the singulator there were only 4 clusters remaining intact (Table 5-1). This represents a 67 percent improvement in the number of non-clustered berries. In other words, there were 67 percent fewer clusters after singulation.

The function of the singulator is to decrease the number of berry clusters prior to decapping. A flow of single stemmed berries onto the decapper reduces the berry flesh loss and assures a more uniform and complete removal of the entire calyx.

Table 5-2 lists the daily and season's average for the decapper. The decapper averaged 1215 kg per hour (2679 lbs/hr) for the season with a discharge rate of 20% roll-back, 20% roll-over, 37% cut fruit, and 23% trash material.

The table shows that an excessively high flow rate of material onto the decapper increases the percent of roll-overs. A flow rate greater than 2500 pounds per hour tends to increase the percent of rollovers above that of the seasons average which was 20 percent. This is due to over filling of the inclined bed therefore the excess fruit is not caught by the rollers but lodged between or on top of the other fruit and carried over the top of the decapper and not allowed to roll back down off the inclined bed.

5.3.1 Decapper Trash

The decapper trash is a combination of plant stems, leaves, calyxes, field debris, and berry flesh. An analysis of the decapper trash found that 46 to 60 percent of the trash removed by the decapper was berry flesh. With this evidence, the processing management may choose to route the decapped berry caps to the finisher for puree, and/or adjust the band-knife blade closer to the rollers to decrease the berry flesh loss to the trash bin.

5.4 Summary

Mechanically handling and processing the machine harvested fruit at the processing plant is the final phase to the total systems approach for the mechanization of the strawberry industry.

The three phases or primary subsystems to the total systems approach for the mechanization of the strawberry industry have been discussed in this and the two previous chapters. The following chapter describes the computer model which was developed to examine the economic feasibility of this cultural and machine harvested, handling and processing system.

CHAPTER VI

MODEL DESCRIPTION AND VERIFICATION

6.1 Introduction

The strawberry production computer model was designed to function interactively with the user. After the user types a command to the computer to start the program, the program begins immediately, and prompts the user with questions. This interactive technique enables the user with no previous computer experience to easily use this production model. Since the model was designed to function interactively with the user, and for the user's convenience, the input and output data for this model are expresed in their common English units, e.g. acres, tons, pounds.

The model was designed with specific purposes in mind: first, to examine the economic feasibility of mechanical harvesting and processing for solid-set strawberries; and second, to be used as a budgeting tool for production costs should the solid-set strawberry production and mechanical harvesting technique prove to be economically feasible.

The model was also designed to be flexible in its parameters so that the values could be easily changed by the user. This would allow the model to benefit researchers, extension agents, and growers alike, who are interested in examining this system. The flexibility of the model to change any of the preprogrammed values enables the user to better simulate their present or projected future enterprise without having to rewrite the computer program.

The output of the model is itemized by operation so that cost observations can be made regarding the system. The model's output is presented in three parts: 1) field production costs, 2) machine and equipment costs, and, 3) economic analysis. The economic analysis segment is a summary of the complete system's cost, product distribution, and product revenue minus the total cost to the strawberry enterprise.

Figure 6-1 shows a conceptual flowchart of the model and Figure 6-2 shows the subroutine flowchart that is initiated by BERRY. An indepth description of the model and the individual subroutines are explained in the following subsections.

6.2 Subroutine Description

The strawberry production model (BERRY) is a linear program composed of a series of call statements to summon the required subroutines which are necessary to complete the economic analysis.

The model begins by prompting the user with general information questions needed by the model to complete the economic analysis for the strawberry production system. The questions asked by BERRY (Figure 6-3) are directed towards the size of the strawberry enterprise, interest rates, fuel price, projected yield, distribution, and selling price for the final product. After the user has completed the questions, the model re-displays the questions with the user's response to each question. This allows the user to check their inputted values with an option to change any one of the values. The information in this segment of the

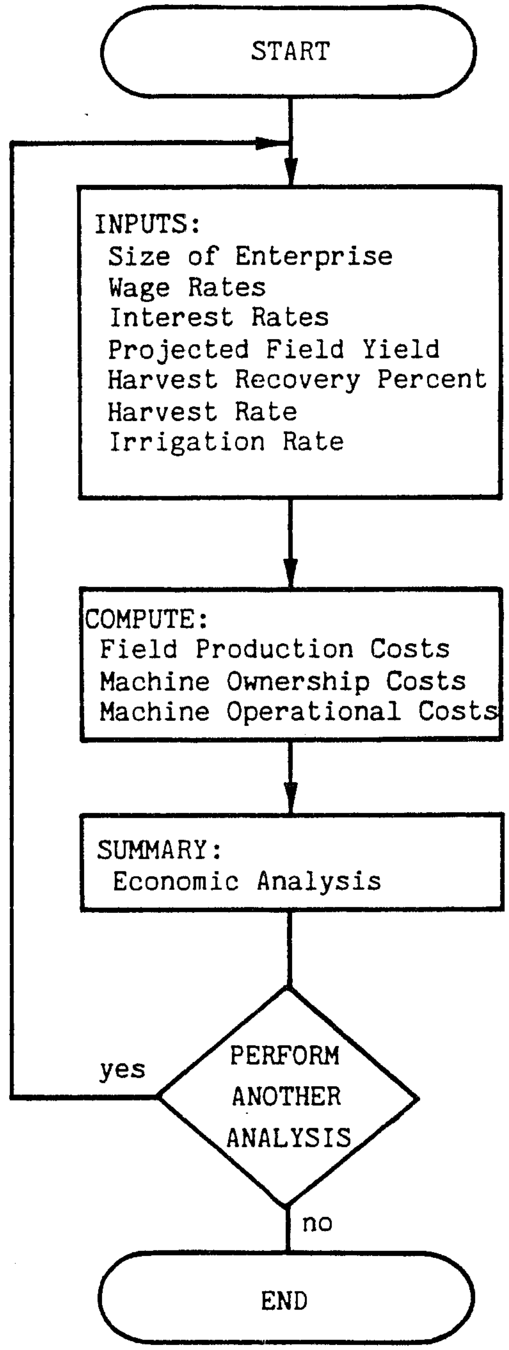


Figure 6-1. Conceptual Flowchart of the Model

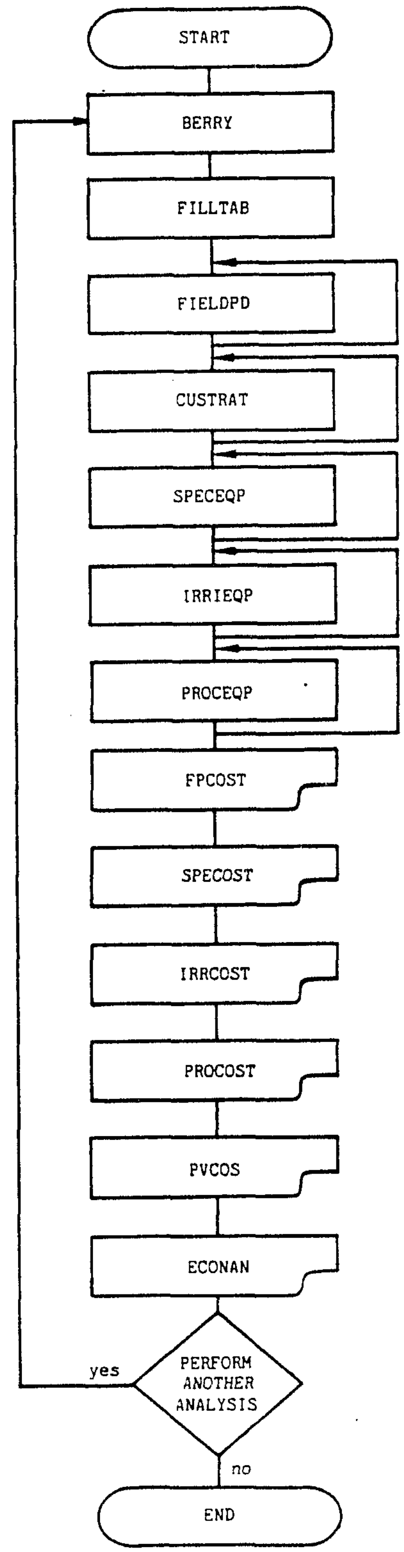


Figure 6-2. Subroutine Flowchart as Initiated by BERRY

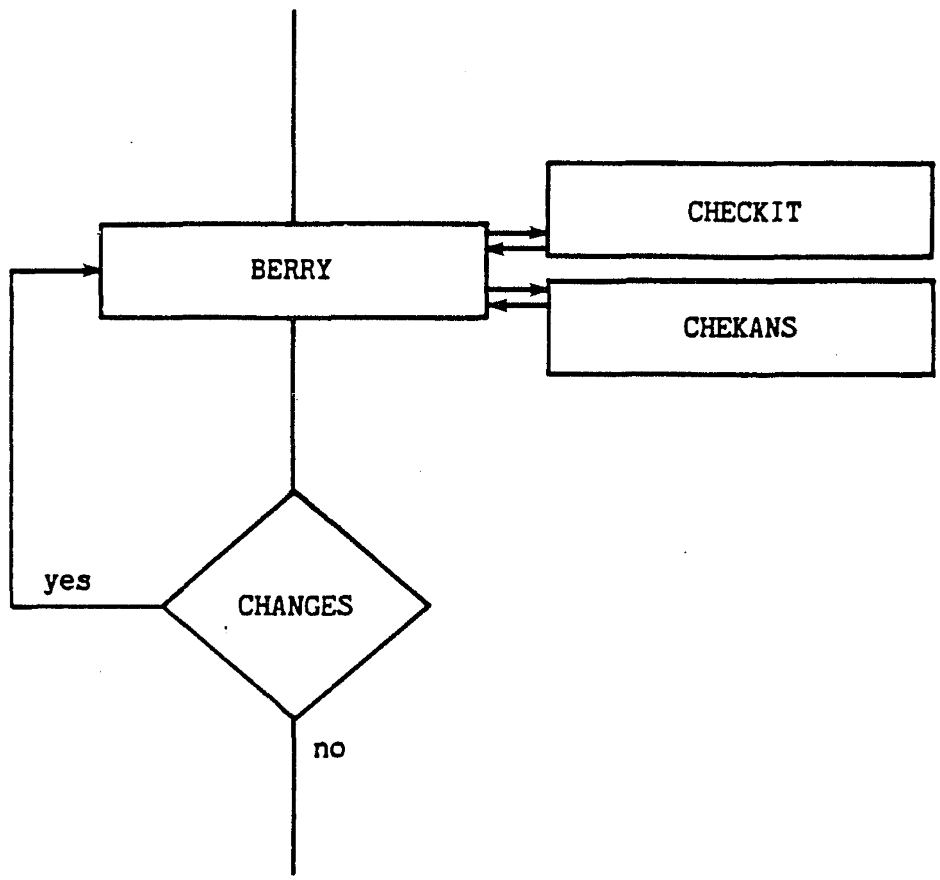


Figure 6-2. Flowchart for the Subroutine BERRY

model is then passed to the remaining subroutines where the information is utilized by the model in completing the analysis.

6.2.1 Subroutine FILLTAB

FILLTAB (Figure 6-4) reads the preprogrammed values from the data file, DATAFL1 into all the data tables in the strawberry production model. The values in FILLTAB are used by the five subroutines FIELDPD, CUSTRAT, SPECEQP, PROCEQP and IRRIEQP in filling out their data tables. After the values have been passed to the subroutines, FILLTAB returns to the main program.

6.2.2 Subroutine FIELDPD

FIELDPD (Figure 6-5) contains the preprogrammed field production material price values and the application rates associated with the field production operations. FIELDPD calls PRINTAB to display the data table. Following the data table, FIELDPD prompts the user to see if they wish to change any of the values within the data table. If the user's response is yes, then CHECKIT and CHGTAB are called for by the model. Between the two subroutines CHECKIT and CHGTAB, they assist the user in making the desired changes. Once the changes have been completed, MENUCHG is called to replace the preprogrammed values with the new values entered by the user. MENUCHG returns to FIELDPD where FIELDPD calls PRINTAB to display the field production data table with the new values. Again, the user is given the option to change the values. However, if the user's response is no, then FIELDPD returns and the program continues with the next segment of the model.

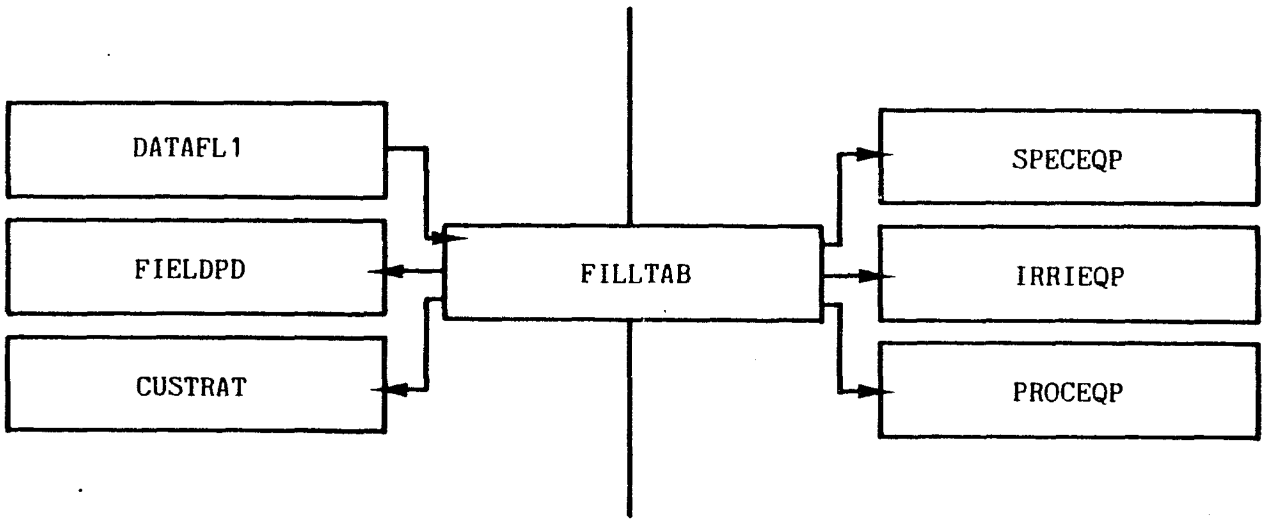


Figure 6-4. Flowchart for the Subroutine FILLTAB

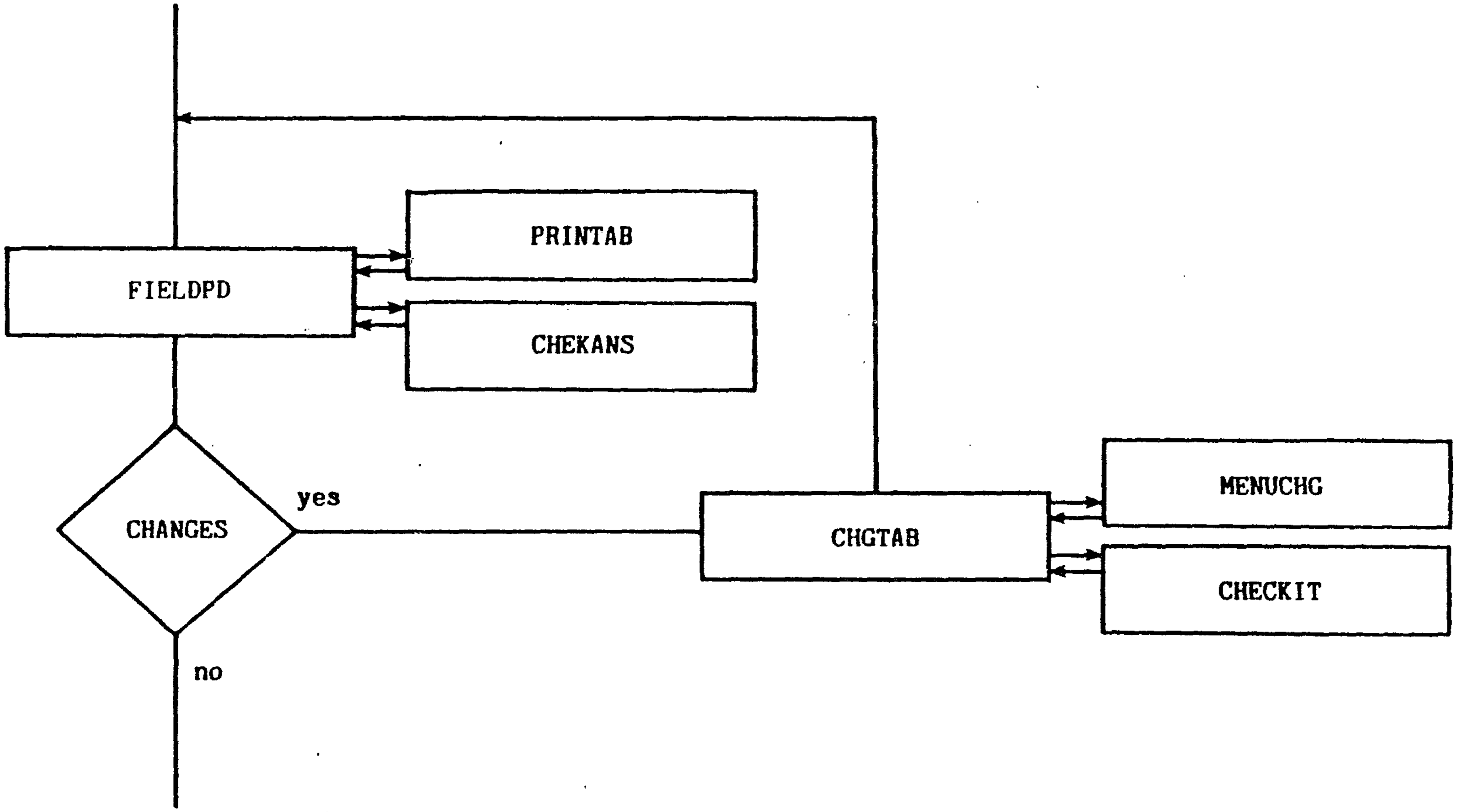


Figure 6-5. Flowchart for the Subroutine FIELDPD

Table 6-1 lists the field production materials and values contained within this subroutine. If no changes are made by the user, then the values in this table are used by the model in calculating the field production costs.

Table 6-1. Field Production Data Table.

Materials	Cost/Unit ($)	Quantity/Acre
Cover-crop (oats)	2.00/bu	2.00 bu/acre
Fertilizer		
12-12-12	174.00/ton	0.25 ton/acre
Nitrogen	136.00/ton	50.00 lbs/acre
Fumigation	400.00/acre	Custom Application
Strawberry Plants	61.00/1000	10890 plants/acre
Pesticides		
Captan	1.10/lb	5.0 lb/acre
Benlate	11.00/lb	1.0 lb/acre
Ronalin	16.80/lb	1.5 lb/acre
Sinbar	16.90/lb	0.5 lb/acre
Thiodan	3.85/lb	2.0 lb/acre

6.2.3 Subroutines CHECKIT and CHEKANS

These subroutines are utilized by the model whenever the user changes any of the values within the model. CHECKIT is an insurance device which gives the user a chance to double check the items which they have selected to enter into the model. CHECKIT calls CHEKANS which interacts with the user to ensure that the value entered by the user is the value they wish to use. Between the two subroutines, CHECKIT and CHEKANS, they prevent the user from completing the model execution with the wrong inputted value.

6.2.4 Subroutine MENUCHG

The subroutine, MENUCHG, changes the preprogrammed values in the data tables for the model. MENUCHG is called by CHGTAB to replace the model's preprogrammed values with the new values entered by the user. The new entries will then be used by the model in completing the economic analysis.

6.2.5 Subroutine CUSTRAT

This subroutine contains the custom hire rates for the custom hire operations available to the strawberry enterprise. CUSTRAT (Figure 6-6) calls PRINTAB to display the preprogrammed custom rate data table to the user and then CUSTRAT prompts the user to see if they wish to change any of the values within the data table. If the response is yes, then the model calls CHECKIT and CHGTAB which interact with the user in making the desired changes in the data table. Once the changes have been completed, MENUCHG is called to replace the preprogrammed values with the new values entered by the user. MENUCHG returns to CUSTRAT where CUSTRAT calls PRINTAB to display the custom rate data table with the new values. Again, the user is given the opportunity to change the values. However, if the user's response would have been no, then CUSTRAT returns and the program continues with the next segment of the model.

Custom hire rates are used by the model as a means for establishing a fair machine cost value to the strawberry enterprise. The custom rates for this subroutine were obtained from the Michigan State University Cooperative Extension Service and are listed in Table 6-2. The rates in Table 6-2 are the averages for the State of Michigan as of August 1983 (Schwab, G.D., 1983).

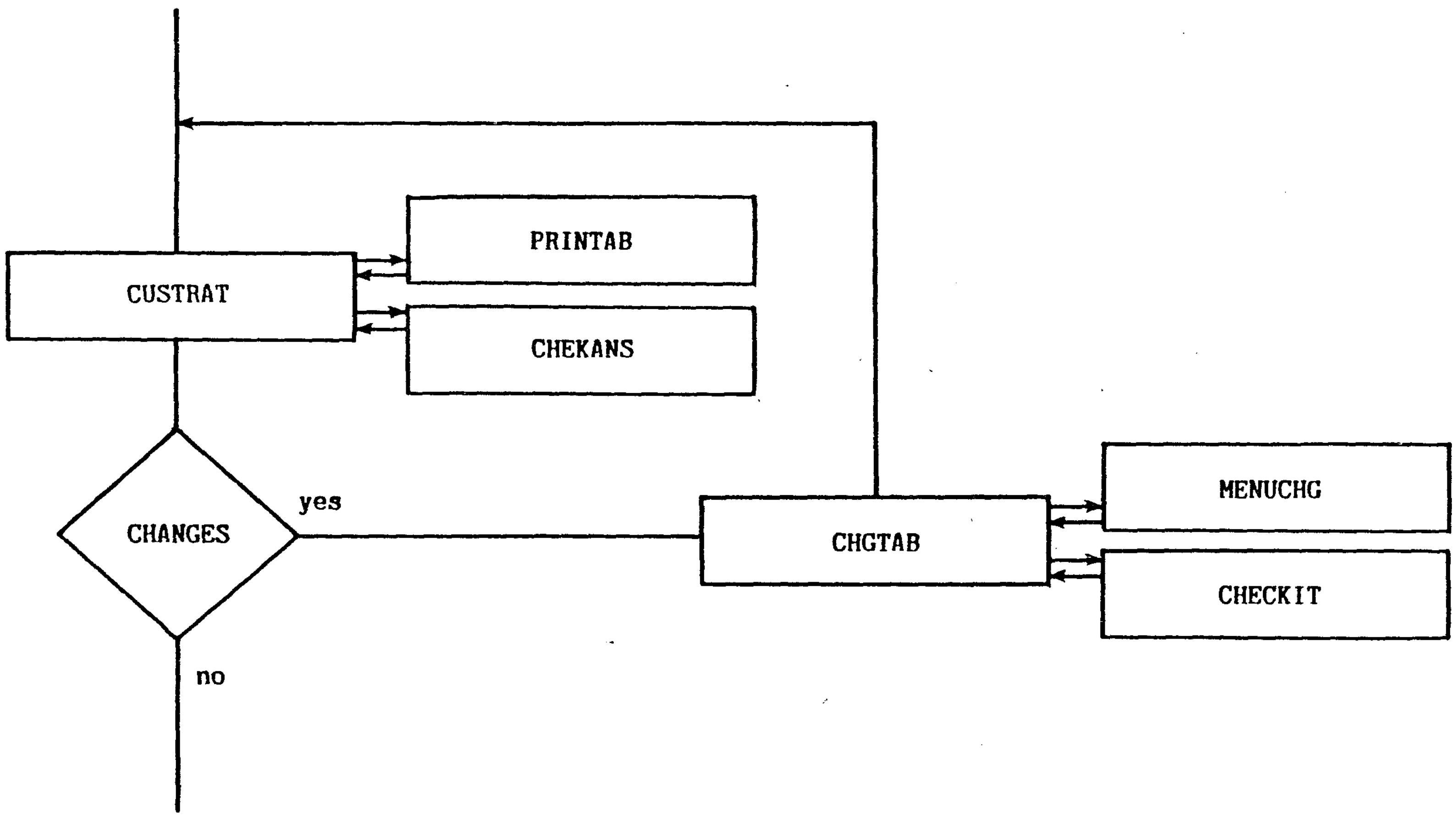


Figure 6-6. Flowchart for the Subroutine CUSTRAT

Table 6-2. 1983 Custom Hire Rates for the State of Michigan.

Operation	Rate ($/acre)
Plow	11.55
Disk	7.85
Cultimulch	5.60
Drilling	5.90
Spraying:	
Ground rig	4.00
Aerial	4.90

6.2.6 Subroutine PRINTAB

This subroutine formats all the data tables for the model. PRINTAB is called for by the individual subroutines to display the data tables to the user for examination prior to the cost calculations as well as the output for the individual subroutine.

6.2.7 Subroutine CHGTAB

This subroutine, in conjunction with CHECKIT, interacts with the user in making the desired changes in the models preprogrammed data values within the data menu tables. CHGTAB prompts the user to enter the new value for the item they wish to change and then calls CHECKIT to confirm the new inputted value with the user. Upon completion of the user's interaction with CHECKIT, CHGTAB then asks the user if there are any more changes to be made within that particular menu table. Should the user's repsonse be yes, then the interaction between the user and CHGTAB continues, otherwise CHGTAB returns to the subroutine which summoned it to display the new menu table values to the user. Again the user is given the opportunity to change the values within the menu table should they wish.

6.2.8 Subroutine SPECEQP

The subroutine SPECEQP (Figure 6-7) contains the specialty equipment items listed by machine value, machine quantity, and machine cost values. SPECEQP calls PRINTAB to display the specialty equipment and their values to the user. Following the display of the data table, SPECEQP prompts the user to determine if they wish to change any of the equipment values. If the user's response is yes, then CHGTAB calls MENUCHG and CHECKIT. CHGTAB interacts with the user in making the desired changes and then returns to SPECEQP where PRINTAB is called to re-display the specialty equipment data table with the new values. However, if the user's response was no, then SPECEQP returns and the program continues with the next segment of the model.

Table 6-3 lists the specialty equipment machine values contained within the model. The machine costs were obtained from the University of Minnesota, Agricultural Extension Service, "Minnesota Farm Machinery Economic Cost Estimates for 1984." The machine life and repair cost values were obtained from Kepner, Bainer, and Barger (1978), Principles of Farm Machinery, 3rd Edition, Page 34 (Table 2.1). For the machines not listed in Kepner, Bainer, and Barger, the repair cost values for comparable machines were used. For example, the repair cost value for the self-propelled combine was used for the repair cost value for the strawberry harvester.

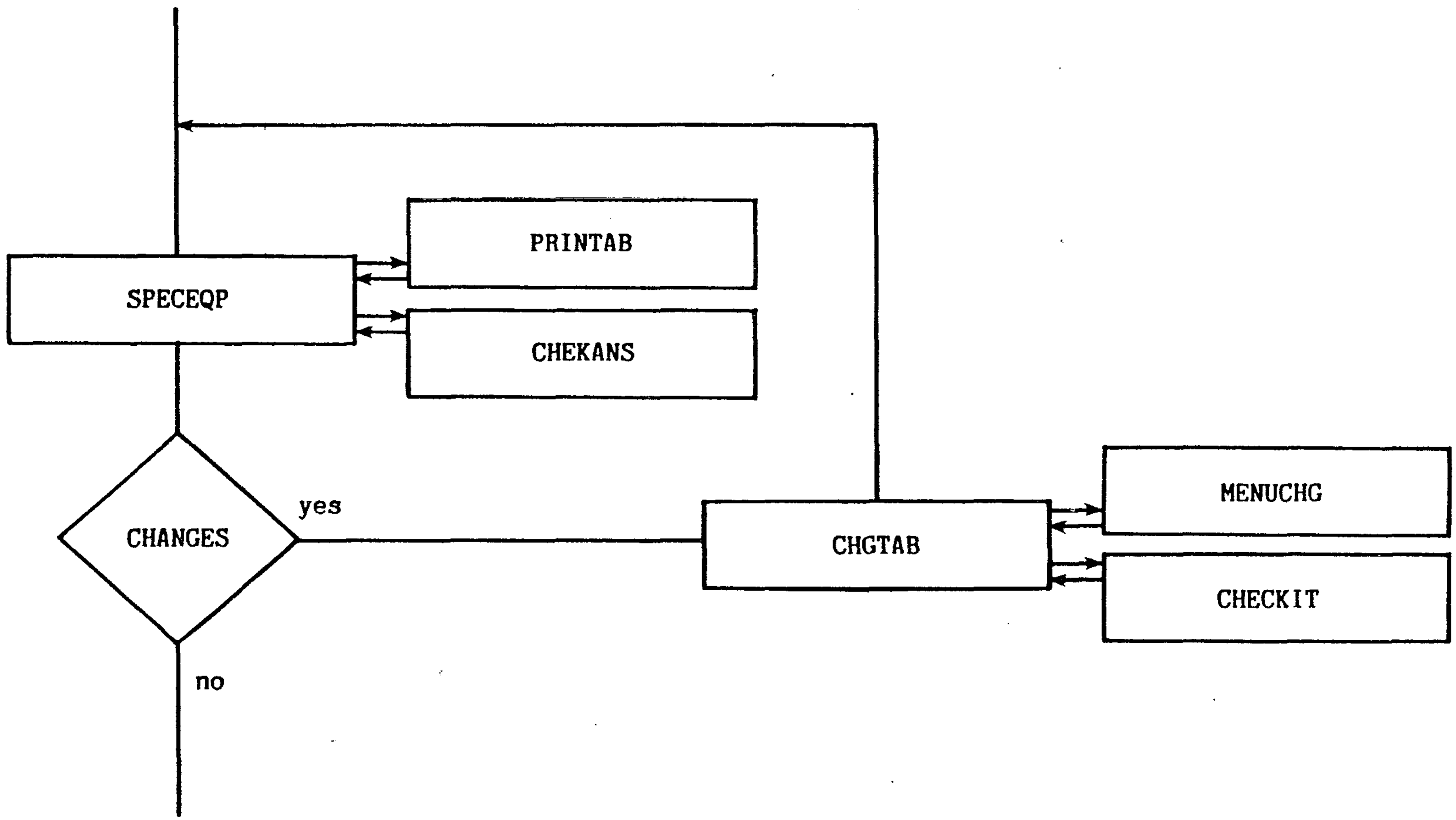


Figure 6-7. Flowchart for the Subroutine SPECEQP

Table 6-3. Specialty Equipment Data Table

ITEM	Inital Cost	Quantity	Machine Life(yr)	T.I.S.[1]	R + M of I.C.[2]
Tractor	15,000.00	1	15	.01	.00010
Forklift Attachment	1,300.00	1	15	.01	.00020
Transplanter (2 Row)	1,150.00	1	15	.01	.00075
Field Roller	1,000.00	1	10	.01	.00040
Harvester	70,000.00	1	10	.01	.00025
Pallet Boxes	20.00	80	10	.01	.01000

1 T.I.S. = Tax, Insurance, and Shelter expressed as a percent of initial cost.

2 R + M of I.C. = Repair and Maintenance expressed as a percent of initial cost.

6.2.9 Subroutine IRRIEQP

IRRIEQP contains the irrigation equipment cost values for the model (Figure 6-8). Prior to printing the irrigation equipment data table, IRRIEQP calculates the estimated initial cost for the complete irrigation system based on a cost per acre basis for the equipment. The estimated cost per acre for the pump set and the pipes and sprinkler equipment were obtained from the Sprinkler Irrigation Supply Company, Royal Oak, Michigan and Eugene Ashcraft of Ashcraft Farms, Copemish, Michigan. They determined that on a per acre basis, the pump set would cost approximately $450 per acre and that the pipe (main and lateral) and sprinkler system would be approximately $1,760 per acre. In this model, based on the above information, the pump set cost per acre was set at $450 and the pipe and sprinkler cost per acre was set at $1,760. The complete irrigation system cost is calculated by multiplying the cost per acre for each item by the size of the strawberry enterprise acreage. The value ACRES is passed from BERRY to IRRIEQP for this calculation.

Pump Set initial cost = 450 * Acres

Pipe & Sprinkler initial cost = 1,760 * Acres

During the re-establishment period for the strawberry acreage, the model increases the cost of the pipe and sprinkler set by 20 percent. The model assumes an annual 20 percent re-establishment acreage to begin the fall of year 4, however, the extra irrigation system capacity is not utilized until year 5. In otherwords, the land area for the strawberry enterprise is held constant for the first four years and increases only once by 20 percent during the fall of the fourth year. This allows 20 percent of the starwberry acreage to be re-established each year, there-

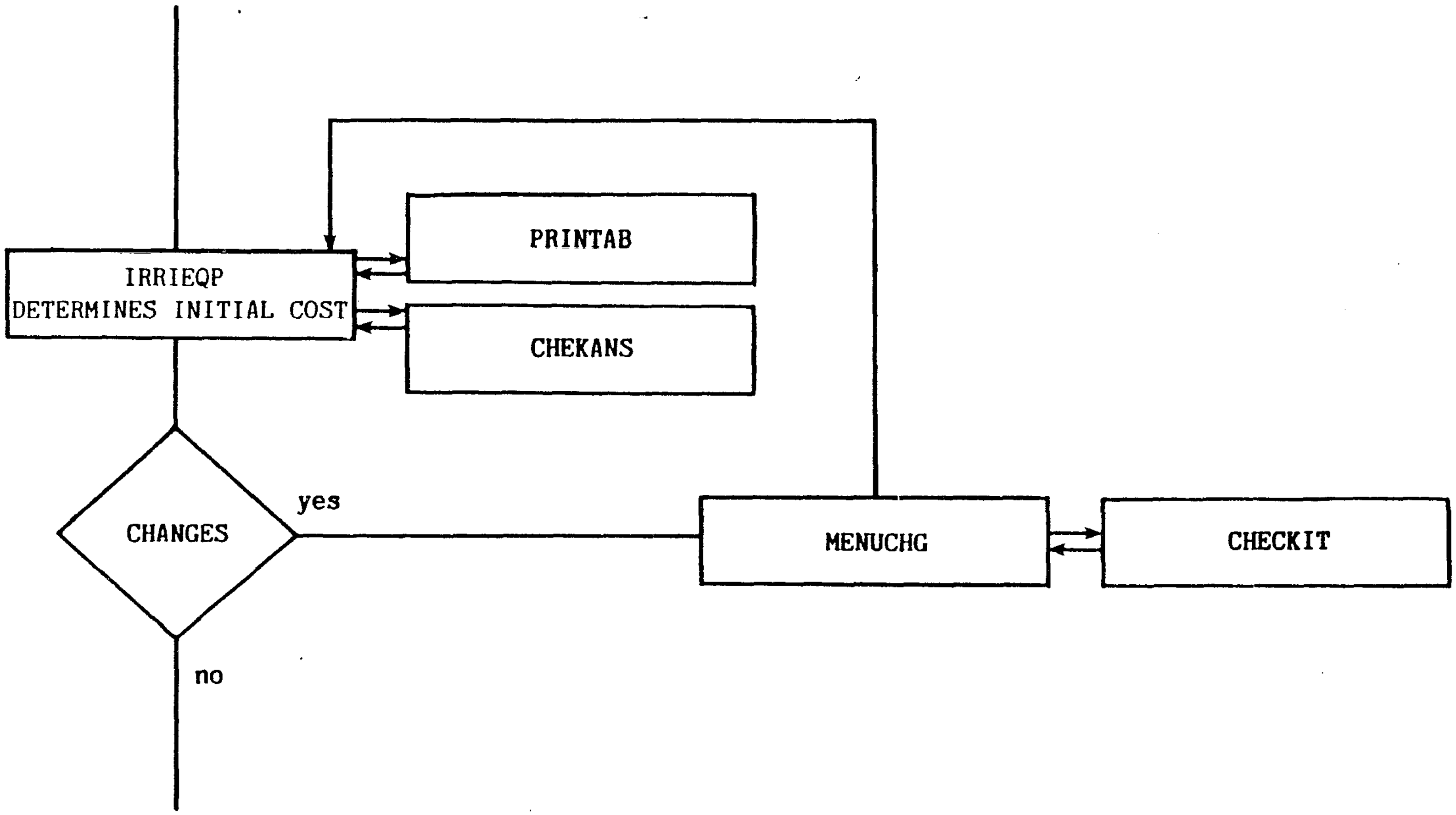


Figure 6-8. Flowchart for the Subroutine IRRIEQP

fore keeping the producing strawberry acreage the same as the grower originally began with.

This increased equipment cost to the enterprise is included in the annual cost to the enterprise starting in the fifth year. The model assumes that the original pump set was adequately sized to handle the 20 percent increase in the acreage.

After the model calculates the initial cost for the irrigation system, IRRIEQP calls PRINTAB to display the irrigation data table. IRRIEQP then prompts the user to see if they wish to change any of the values. If the response is yes, IRRIEQP calls MENUCHG. MENUCHG and CHECKIT function interactively with the user to make the desired changes. MENUCHG replaces the original values with the new values entered by the user. MENUCHG returns to IRRIEQP where IRRIEQP calls PRINTAB to display the irrigation data table with the new values. Again, the user is given the option to change the new values. However, if the user's response is no, then IRRIEQP returns and the computer program continues with the next segment of the model.

6.2.10 Subroutine PROCEQP

This subroutine contains the processing equipment items listed by machine value and quantity of each machine as determined by the final product distribution selected by the user in the main program BERRY. PROCEQP (Figure 6-9) calls PRINTAB to display, in a table format, the machine costs and quantities. PROCEQP then prompts the user to see if the user wishes to change any of the values. If the response is yes, CHECKIT and CHGTAB are called to assist the user in making the desired changes. Once the changes have been completed, MENUCHG is called to

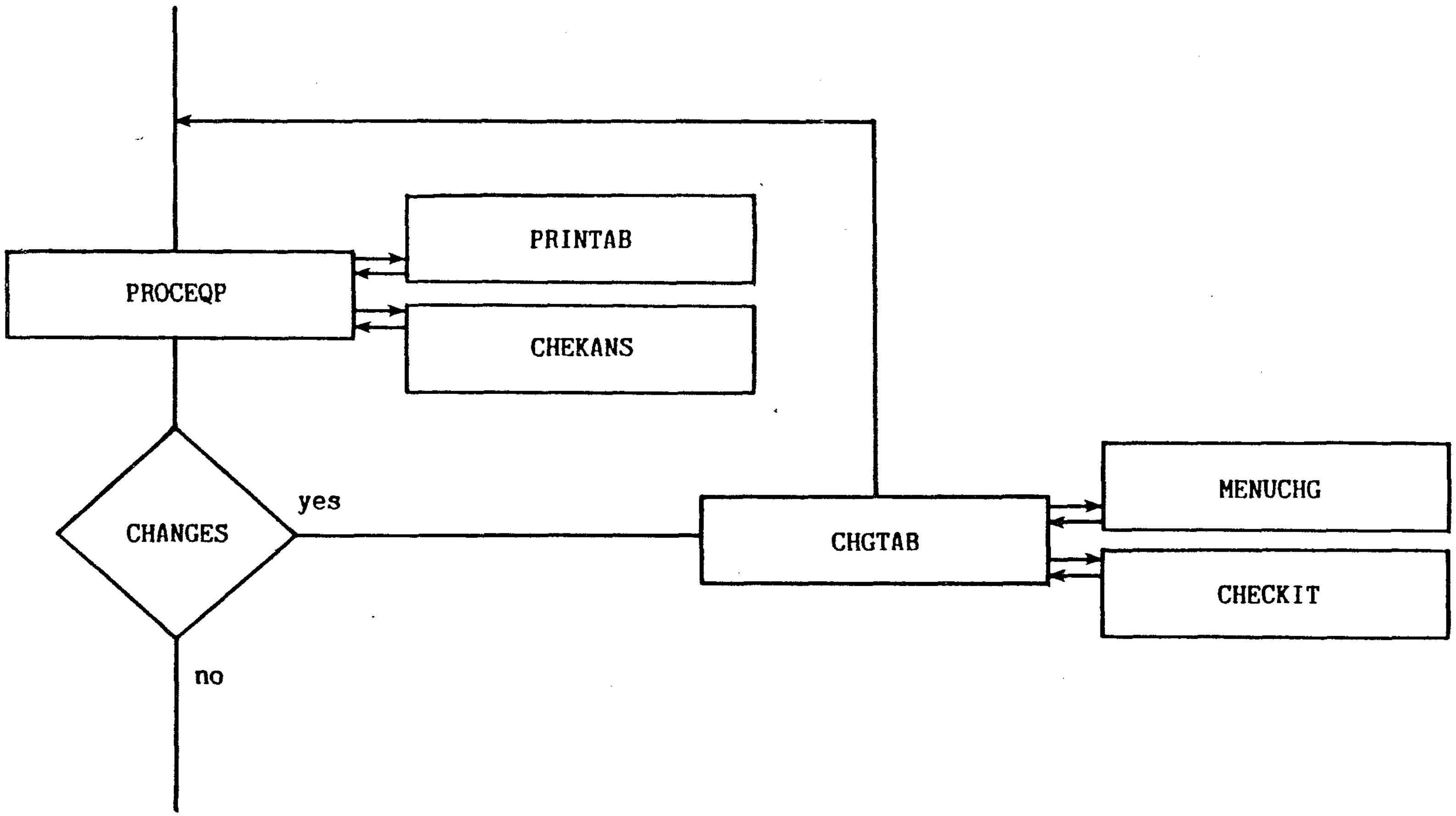


Figure 6-9. Flowchart for the Subroutine PROCEQP

replace the preprogrammed values with the new values entered by the user. MENUCHG returns to PROCEQP, there PROCEQP calls PRINTAB to display the processing equipment data table with the new values. Again, the user is given the option to change the values. However, if the user's response is no, then PROCEQP returns and the program continues with the next segment of the model.

Tables 6-4 and 6-5 list the processing equipment machine values contained within the model. The machine values are based on the 1983-84 prices.

Table 6-4. Processing Equipment Data Table, Processing Option Number One.

Item	Initial Cost	Quantity
Dump Tank	1,000.00	1
Finisher	3,500.00	1
Conveyors	1,300.00	6
Singulator	8,000.00	1
Decapper	20,000.00	2
Sizer	3,200.00	1
Slicer	2,500.00	1

Table 6-5. Processing Equipment Data Table,
Processing Option Number Two.

Item	Initial Cost	Quantity
Dump Tank	1,000.00	1
Finisher	3,500.00	1
Conveyors	1,300.00	3

6.2.11 Subroutine FPCOST

The subroutine FPCOST (Figure 6-10) utilizes the data information from the subroutines BERRY, FIELDPD, CUSTRAT, SPECEQP, and IRRIEQP to compute the field production costs for the strawberry enterprise. FPCOST calculates and displays an itemized crop production cost on a yearly basis for 10 years followed by an average cost for the 10-year period.

6.2.12 Subroutine SPECOST

The subroutine SPECOST calculates the annual cost per year for the specialty equipment. SPECOST (Figure 6-11) receives its machine values from SPECEQP and calculates the machine cost by using the conventional fixed-variable cost analysis method utilizing the straight-line depreciation method. The fixed-variable cost analysis method results in the annual cost associated with an investment based on its period of owner-

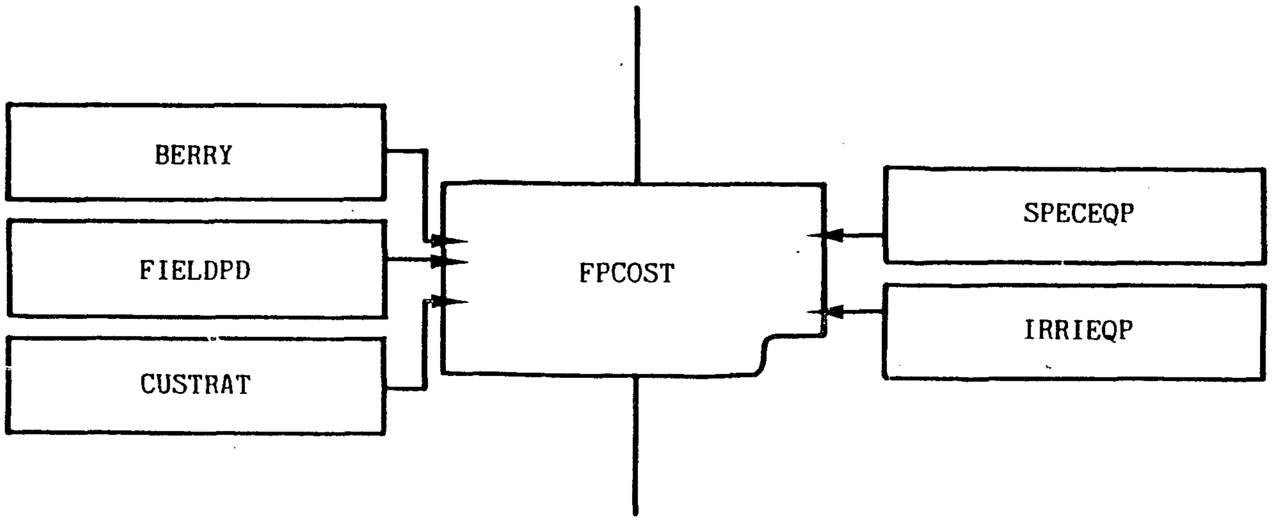


Figure 6-10. Flowchart for the Subroutine FPCOST

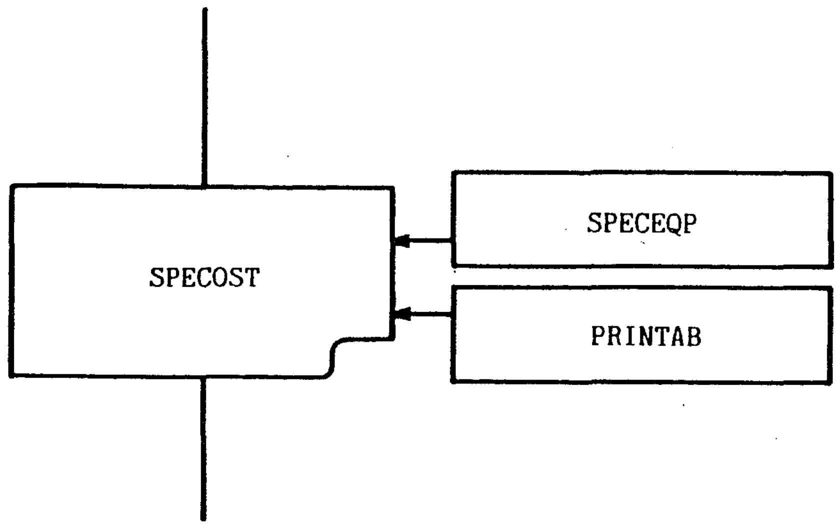


Figure 6-11. Flowchart for the Subroutine SPECOST

ship. The fixed costs (the costs which are independent of the machine use) include depreciation, interest on the investment, the property tax, insurance, and shelter. Variable costs are the machine costs which are directly related to the amount of machine use. These costs include repair and maintenance, fuel and lubrication, and labor. The total machine cost is the sum of all the fixed and variable costs.

The procedure for calculating the fixed-variable cost analysis method is described in the American Society of Agricultural Engineers Yearbook of Standards 1983-84, Section EP391 Agricultural Machinery Management, as well as in many of the current farm machinery management books, such as Hunt, 1978; Bowers, 1975; and Kepner, Bainer and Barger, 1978.

Upon completion of the cost analysis, SPECOST calls PRINTAB to display the specialty equipment fixed and operational cost table. The cost analysis for each machine is listed as a fixed cost per year, fixed cost per acre, operational cost per acre, and total cost per acre.

6.2.12.1 Repair and Maintenance

The repair and maintenance cost for the specialty equipment are expressed as a percent of the machines' initial cost. These values were obtained from Kepner, et al., 1978. For the machine not listed in Kepner, et al., a comparable machine's repair and maintenance percent was listed in SPECEQP.

6.2.12.2 Fuel Cost

The fuel cost was based on the average annual fuel consumption estimate as outlined in the 1983-84 Agricultural Engineers Yearbook of

Standards. The average annual fuel consumption was estimated by the following formula:

Average Diesel Consumption (gal/hr) = 0.043 * max. PTO hp

6.2.12.3 Labor Cost

The model considers two labor wage rates ($/hr). The labor wage rates are passed by the model from the subroutine BERRY to SPECOST for labor cost calculations. One wage rate is used by the model for the machine operator and another for the laborers. Generally, the operator receives a higher wage rate due to the technical skills required by the operator, and a lower rate for the laborers who provide manual services.

6.2.13 Subroutine IRRCOST

IRRCOST (Figure 6-12) calculates the annual irrigation equipment cost by using the irrigation equipment values from IRRIEQP and the conventional fixed and variable cost analysis method. The fixed costs include depreciation, interest on the investment, and property tax, insurance, and shelter. The variable costs consists of repair and maintenance and electricity for the pumping system.

The irrigation costs were derived from engineering data and formulas for an electric motor pump set with a sprinkler irrigation system. (Turner and Anderson, 1980). The cost calculation is based on the following assumptions:

1. The life of the pump set is 15 years with a 10 percent salvage value.

2. Electric motor is used as the power unit.

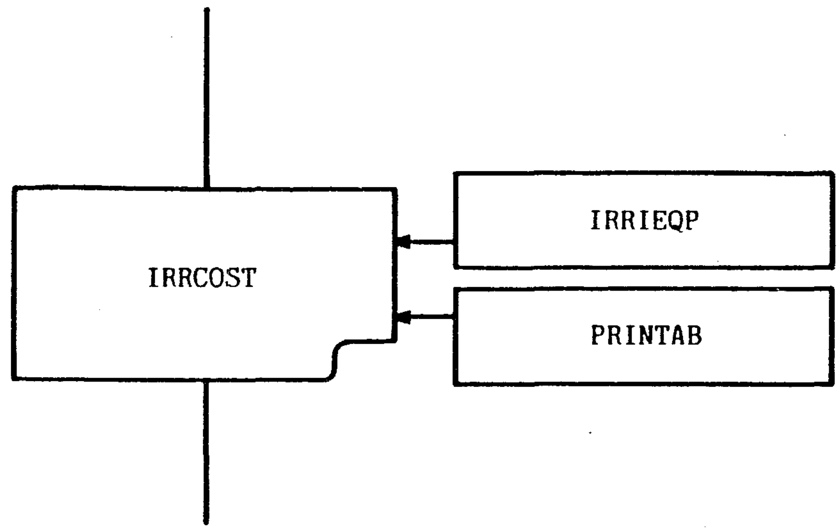


Figure 6-12. Flowchart for the Subroutine IRRCOST

3. The life of the pipes and sprinklers is 30 years with a 10 percent salvage value.
4. The electricity value is set at $.10 per KWHR.
5. The tax, insurance and shelter (T.I.S.) are set at 1 percent of the initial cost.
6. Interest rate is a user input value obtained from the subroutine BERRY.
7. The repair and maintenance costs are estimated by a percent of the initial pump set cost. Seven percent was used for this value.

Since the model assumes a 20 percent increase in the strawberry enterprise acreage to begin the fall of year 4, the value of the pipe and sprinkler set is increased by 20 percent during year 5. Consequently, there is a 20 percent increase in the cost of the pipe and sprinkler system. The pump set is not increased since the assumption was made that the original pump set was adequately sized to handle the 20 percent increase. Therefore, the average annual irrigation cost for the pipe and sprinkler system is based on a ten year cost average for the pipe and sprinkler system.

The electricity cost for the irrigation system is based on the amount of water applied per year from an adjacent surface water supply. The quantity of water applied per year is dependent upon the soil type, rainfall during the particular growing season, and the number of frost control applications required during the growing season. The quantity of water applied per year is an input value required by the user in the subroutine BERRY.

Upon completion of the cost analysis, IRRCOST calls PRINTAB to display the irrigation equipment fixed and operational cost table. The cost analysis for irrigation system is listed as a fixed cost per year, fixed cost per acre, operational cost per acre, and total cost per acre.

6.2.14 Subroutine PROCOST

This subroutine calculates the annual fixed cost per year for the processing equipment. PROCOST (Figure 6-13) receives its machine values from PROCEQP and calculates the machine cost by using the fixed cost analysis method with the straight-line depreciation method. The fixed cost includes: depreciation, interest on the investment, property tax, insurance, and shelter. Upon completion of the cost analysis, PROCOST calls PRINTAB to display the processing fixed cost table. The cost analysis for each machine is listed on a cost per year and a cost per acre basis.

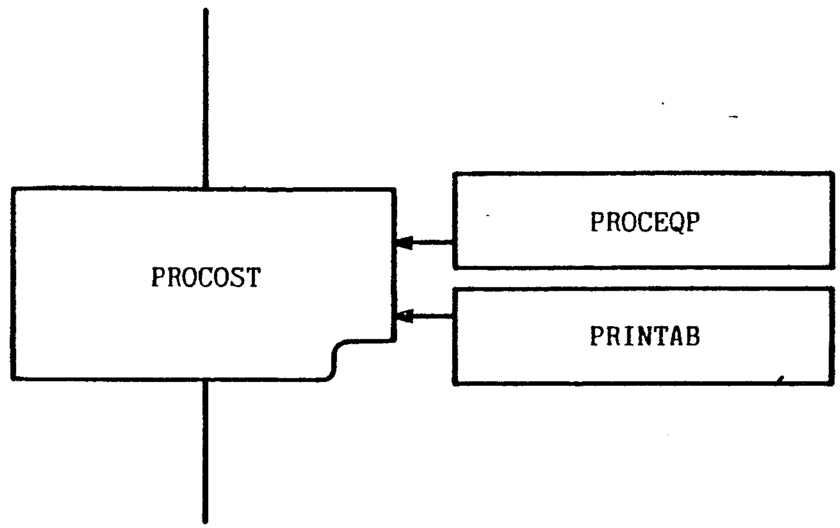


Figure 6-13. Flowchart for the Subroutine PROCOST

6.2.15 Subroutine PVCOS

This subroutine calculates the operating costs associated with the processing operation (Figure 6-14). The variable costs include the equipment repair and maintenance, labor, and the general operating expense for the electricity, and the building and freezer rent.

The repair and maintenance costs are estimated as a percent of the initial equipment investment. The repair and maintenance cost estimate ranges from 3 percent of the initial investment for simple equipment to 13 percent for more complex and corrosive systems (Humphreys and Katell, 1981). Based upon this information, the model assumes the repair and maintenance costs for the processing equipment to be 3 percent of the initial equipment investment. The remainder of the processing operational costs are dependent upon the quantity of the raw product received at the processing plant and the general operating cost of the processing plant. The general operating cost is set at $.05 per pound and includes the items: electricity, water, one foreman, containers for the final fruit product, and the rent for the building and freezer.

The projected material handling rate (PMHR) at the processing plant is determined by the final product option selected by the user in the subroutine BERRY. The PMHR is necessary for calculating the total processing labor cost and the general processing expense. If the selected processing option was number one (Product processed as freezer pack and puree), then the PMHR is determined by the number of decappers used in the processing system with a rated capacity of 3000 pounds per hour per decapper. With option number one, the model assumes the number of processing plant employees to be 15. However, if the selected option was number two (100% of the product processed as puree) then the PMHR is

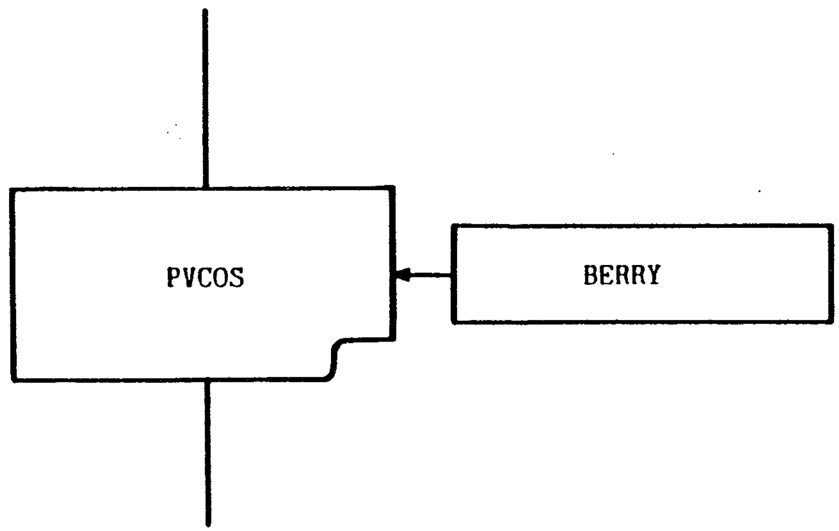


Figure 6-14. Flowchart for the Subroutine PVCOS

determined by the number of finishers used in the processing system with the rated capacity of 6,000 pounds per hour per finisher. With option number two, the model assumes the number of processing plant employees to be 9.

The output for PVCOS displays the season's repair and maintenance cost, general expense, total number of processing hours, labor cost, and the total processing cost expressed on a per year and per acre basis.

6.2.16 Subroutine ECONAN

This subroutine completes and summarizes the economic analysis for the strawberry enterprise (Figure 6-15). ECONAN calculates the economic analysis by combining the cost estimates from FPCOST (Based on the 10-year crop production average), SPECOST, IRRCOST, PROCOST and PVCOS with the estimated product revenue. The final product revenue minus the production costs for the model are based upon the production costs and final product values entered by the user. ECONAN summarizes the complete production system by listing the 10 year field production cost average, the annual machine fixed costs, harvesting and processing cost for the enterprise, followed by the estimated final product distribution and revenue for the enterprise.

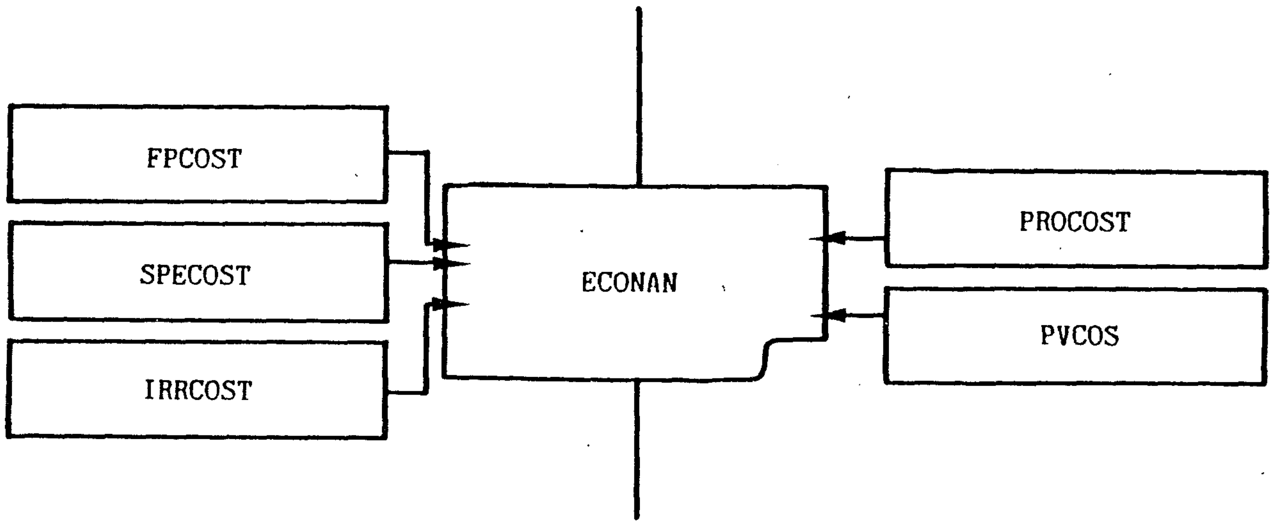


Figure 6-15. Flowchart for the Subroutine ECONAN

6.3 Model Verification and Validation

6.3.1 Model Verification

The model was verified by comparing the model output with that of hand calculations to ensure that the model was mathematically sound and functioning as it was designed.

6.3.2 Model Validation

The model was validated by performing an economic analysis for the Michigan growers, based on the 1984 harvest season cost price structure. The validation for the model was performed in the areas: 1) field production costs, 2) machine cost analysis, and, 3) harvest and processing costs. The field production validation was based largely on the published literature for the production materials and chemical application rates along with the known information from the researchers and growers of the present technology. Custom hire rates were used by the model for the field production operations as a means of establishing a fair machine cost to the enterprise. This provided an actual cost per acre to the strawberry enterprise and avoided the conflict of establishing a cost per acre for the field machinery based on the size of the total farm acreage.

The ownership cost estimates for the specialty, processing and irrigation equipment should be the most accurate segment of the model for they are based on physical cost analysis principals. Whereas the variable machine cost estimates for the harvesting and processing operations were based on the cost estimates established during the 1983 season.

The validation for the harvest and processing costs were based on the actual costs incurred by the growers with the exception of the raw field product transport cost. The raw product transport cost ($/cwt) was based on the custom hire transport rate published for the State of Michigan (Schwab, G.D., 1983).

In the case of the processing variable cost, the model predicted the processing cost for the 1984 season to range from 6 to 7 cents per pound for the raw product to be processed as 100 percent puree. The processing cost per pound is based on the quantity of the product received at the processing plant, the method of processing, and the distribution of the final product. The prediction by the model coincided with the actual cost encountered by the growers.

In conclusion, the final segment of the model virtually calculates and summarizes the economic analysis for the strawberry enterprise production system. The model calculates the net cash return per acre to the strawberry enterprise but this does not include the land value. The land cost value, either land ownership or land rent costs were omitted from the model due to the great fluctuation in land values throughout the state of Michigan. Therfore, the model was designed to show only the estimated net cash return per acre to the enterprise. Consequently, the user must subtract their land ownership costs or land rent costs from the model's estimated net cash return to obtain their predicted net cash return.

6.4 Sensitivity Analysis

A sensitivity analysis was completed to study the response of the model due to a parameter change within the system model. In conducting the sensitivity analysis, only one parameter was changed per test. This permitted easy recognition of what happened to the system as a result of that particular parameter change.

6.4.1 Effect of the Crop Yield

In this test, the projected field yield (YPA) was changed to examine the effect of the raw product yield upon the costs and net return per acre to the enterprise. The cost analysis for this test was based on the enterprise size of 20 acres with a harvest rate of 0.29 acres per hour (3.5 hrs/acre) for the following yield levels of 7.5, 10, and 12.5 tons per acre. The raw product was processed as puree with a final product value of $.30 per pound.

As expected, the model reflected a change in the harvest variable cost due to the change in the transport cost as well as a change in the processing cost and the quantity of the final product (Table 6-6).

Table 6-6. Effect of Crop Yield on the Enterprise Cost and Final Product Quantity.

	Yield Level		
Per Acre	7.5 Tons	10.0 Tons	12.5 Tons
Harvest cost	268.34	293.34	318.34
Processing cost	875.10	1,162.60	1,450.10
Final product quantity (tons)	6.75	9.00	11.25

6.4.2 Effect of Harvest Rate

In this test, three harvest rates were used to examine the effect of the harvest rate on the system cost. As expected, a change in the harvest rate was reflected only in the harvest cost, specifically in the harvester and forklift variable costs (Table 6-7).

Table 6-7. Effect of Harvest Rate on the System Cost.

	Harvest Rate (hrs/acre)		
	3.0	3.5	4.0
Variable Cost per Acre			
Harvester	119.59	140.21	162.64
Forklift	34.78	40.77	47.30
Total Harvest Cost	154.37	180.98	209.94

Table 6-7 shows that an increase in the harvest rate or, in other words, an increase in the effective field capacity (EFC) of the harvester, results in a decrease in the variable cost per acre for both the harvester and the forklift. The fluctuation in the harvest cost is due to the change in the fuel and labor expense.

As mentioned earlier, the EFC for the forklift is set by the model to equal that of the harvester. This is because the forklift operation cannot be completed any sooner than that of the harvester for the forklift is needed to load and unload the transport vehicle.

6.4.3 Effect of Interest Rates on the System

A sensitivity test was done to study the effect of an increase in the interest rate on one of the three equipment subsystems within the strawberry production system. With the remaining equipment's interest rates held at 14 percent, the interest rate for the irrigation system was increased by 2 percent from 14 to 16 percent. Table 6-8 was constructed to show the effect of the 2 percent interest rate change on the annual fixed cost for a 20 acre irrigation system.

Table 6-8. Effect of an Interest Rate Change for the Irrigation System Upon the Total System's Cost.

A. Irrigation equipment fixed cost based on a loan interest rate of 14 percent.

Item	Fixed Cost Per Year
Pump Set	1,323.00
Pipe and Sprinkler	4,612.61
Total Fixed Cost	5,935.61

B. Irrigation equipment fixed cost based on a loan interest rate of 16 percent.

Item	Fixed Cost Per Year
Pump Set	1,422.00
Pipe and Sprinkler	5,046.27
Total Fixed Cost	6,468.27

6.4.4 Effect of a Change in the Production Costs on the Break-even Acreage

In this test, the production costs (crop, harvest, and processing) for the strawberry enterprise were increased and decreased by 10 and 20 percent above and below the 1983-84 costs to examine the effect that this would have upon the break-even acreage to the strawberry enterprise. The only variables held constant during these tests were the harvest rate and the final product puree value. The harvest rate was set at 0.29 acres per hour (3.5 hours per acre) and the final product was processed as 100 percent puree with a puree value of $.30 per pound.

Figure 6-16 shows that based on the 1983-84 production costs, the break-even acreage for the strawberry enterprise would be approximately six acres. A 10 percent decrease in the system's cost would reduce the break-even acreage to approximately five acres and to four acres should the costs fall 20 percent below that of the 1983-84 costs. Whereas a 10 and 20 percent increase in the 1983-84 product cost would increase the break-even acreage to approximately 7.25 and 8.75 acres, respectively.

A potential reduction in the system's production costs, specifically the harvester cost is not an unrealistic possibility for the agricultural engineers at Michigan State University are currently designing a tractor mounted strawberry harvester. This tractor mounted harvester will reduce the cost of the harvester.

The reduction in the cost of the harvester is only one of the potential areas inwhich the system's costs can be reduced. With time, genetically new strawberry plant varieties, pesticides, and fertilizers could be developed which could reduce the crop production costs to the enterprise.

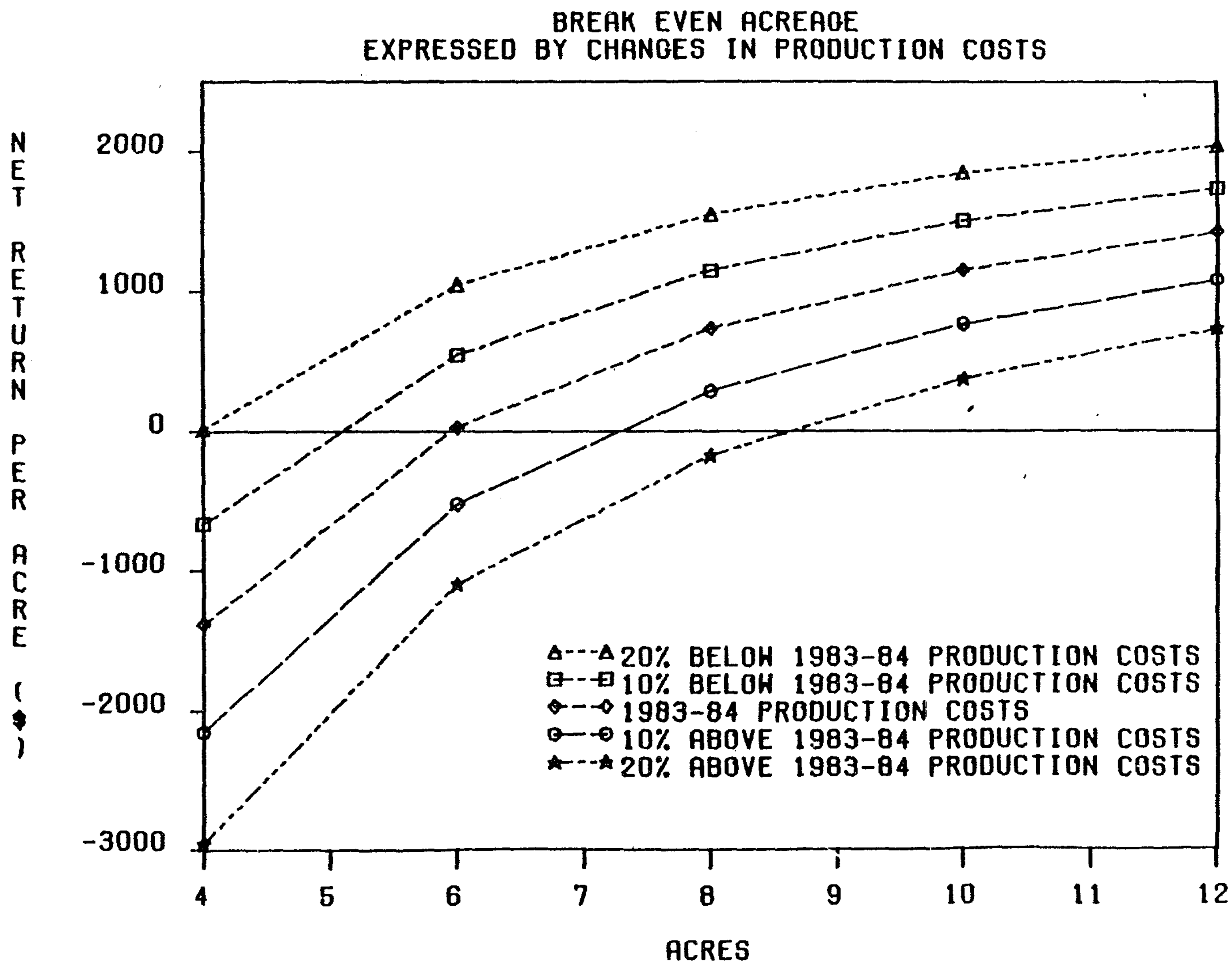


Figure 6-16. Break Even Acreage Expressed by Changes in Production Costs

6.5 Summary

A computer model was designed, built, and implemented to examine the outcome of the model to that of the real world situation. As mentioned in Chapter II, Section 2.1.4, it is not always possible to completely validate a model due to a lack of sufficient information or perhaps the new system may not yet exist in which to obtain this information. However, in the case of the strawberry production model, the model was validated by comparing the results of the model with that of the actual cost information available from the growers presently utilizing this technology. As a result, the model was proven to be mathematically sound and realistically predicted the production costs and the potential net cash return to the strawberry enterprise.

CHAPTER VII

RESULTS AND DISCUSSION

7.1 Economic Evaluation of the Production System

The focus of this chapter is on the evaluation of profitability of mechanical harvesting and processing for the solid set strawberry production system. The analysis was conducted based on the distribution of the final product to determine the break-even acreage and the break-even yield for the production system.

7.2 Determining the Break-Even Acreage

Analysis was performed to determine the break-even acreage which would result from using the required field machinery and processing equipment set deemed necessary for the solid set strawberry production system. The cultural practices, such as the strawberry plant density, and the fertilizer and pesticide application rates were projected to be representative of a typical solid set production system.

Table 7-1 lists the total annual fixed and variable costs on a per acre basis for a strawberry production equipment set for processing the final product as 100 percent puree. The table shows the annual fixed costs per acre to decline from $3,881.47 at 6.0 acres to $1,761.19 at 40 acres. The table also shows that, assuming a constant average gross cash return per acre, the net cash return per acre would increase from $31.32 at 6.0 acres to $2,189.57 at 40 acres.

Table 7-1. Estimated Average Annual Gross Returns Per Acre, Fixed and Variable Cost Per Acre and Net Returns Per Acre at Designated Acreage Levels

Acreage	Gross Return Per Acre	Fixed Cost Per Acre	Variable Cost Per Acre	Net Return Per Acre
6	$5,400.00	$3,881.47	$1,487.21	$ 31.32
10	5,400.00	2,782.98	1,469.34	1,147.68
20	5,400.00	2,017.86	1,455.94	1,926.20
30	5,400.00	1,818.77	1,451.48	2,129.75
40	5,400.00	1,761.19	1,449.24	2,189.57

Based on a harvest yield of 10 tons per acre with a harvest rate of 3.5 hours per acre and the final product (100 percent puree) price of 30 cents per pound.

The fluctuation in the variable cost per acre is due to expressing the annual repair and maintenance cost for the processing equipment on a per acre basis.

7.3 Effect of Price and Yield Levels on the Average Annual Net Cash Returns

The effect of four yield levels and four final product price values were used to show the approximated break-even yield level and the average annual net returns to the enterprise. For this analysis, the harvest rate was set at 3.5 hours per acre and the enterprise acreage was fixed at 20 acres. This would hold constant the fixed costs per acre. The variable costs per acre would vary to compensate for the changes in the harvest and processing cost. Therefore, changes in the crop yields and the sale price for the the final product processed as 100 percent puree would show variance in the returns to the enterprise. For the purpose of illustration, the four harvest recovery yields of 5, 7.5, 10, and 12.5 tons per acre were chosen and the final product price values for the puree were 15, 20, 25, and 30 cents per pound. The estimated cash return for the above crop yield and final product prices are shown in Table 7-2.

Table 7-2. Estimated Net Cash Returns Per Acre for Four Yield Levels and Four Final Product Prices*

Average Yield (tons/acre)	Price Per Pound			
	$0.15	$0.20	$0.25	$0.30
5.0	-1,498.80	-1,048.80	- 598.80	- 148.80
7.5	-1,136.30	- 461.30	213.70	888.70
10.0	- 773.80	126.20	1,026.20	1,926.20
12.5	- 411.30	713.70	1,838.70	2,963.70

*Ownership costs are based on a 20-acre enterprise.

The results indicate a negative cash return would occur at all four yield levels at $.15 per pound as well as a negative cash return for the low yield level of 5 tons per acre at all price levels including a negative return for the yield level of 7.5 tons per acre for the final product value of $.20 per pound. Positive cash returns would be achieved at $.20 per pound for the larger designated crop yields of 10 and 12.5 tons per acre. Positive cash returns were also realized for the yields of 7.5, 10, and 12.5 tons per acre for the final product values of $.25 and $.30 per pound.

The following formula can be used to determine the actual break-even yield level for a known enterprise system cost and a final product price value.

$$\text{Net Yield} = \frac{\text{Total Fixed and Variable Cost per Acre}}{\text{Price Per Pound of Final Product}}$$

For example, based on the prior assumptions for a 20 acre enterprise system cost with a final product value of $.20 per pound, the break-even net yield would be 8.68 tons per acre.

7.4 Break-Even Distribution of the Final Product

Table 7-3 gives the costs and returns of the final product for the various distributions of the final product when processed as varying proportions of freezer pack and puree. The costs per acre in this table are based on an enterprise size of 20 acres with a harvest rate of 3.5 hours per acre with an actual harvest recovery yield of 10 tons per acre. The price structure established for the final product for this analysis was $.40 per pound for freezer pack and $.20 per pound for puree.

Table 7-3. Distribution of the Final Product and Net Return Per Acre

Final Product Distribution Freezer Pack %	Puree %	Net Return Per Acre
80	20	2,267.02
70	30	1,907.02
60	40	1,547.02
50	50	1,187.02
40	60	827.02
30	70	467.02
20	80	107.02
10	90	-252.98
0	100	126.20 *

Price structure based on $0.40 per pound for freezer pack and $0.20 per pound for puree. System costs are based on a 20-acre enterprise, harvest rate of 3.5 hours per acre with a harvest yield of 10 tons per acre.

*The ownership cost is limited to only the processing equipment needed to process the fruit product into puree

Based on this price structure, Table 7-3 shows that to obtain the economic advantage of purchasing the required processing equipment needed to process the final product as freezer pack and puree, the final product distribution would need to be at least 21 percent freezer pack and 79 percent puree when compared to that of processing the entire field product as 100 percent puree with a puree value of $.20 per pound.

However, when the price structure for the final product is increased to $.45 per pound for freezer pack and $.30 per pound for puree, the break-even ratio between processing the final product as 100 percent puree with a puree value of $.30 per pound to that of processing the final product as freezer pack and puree, would be increased to 27.5 percent freezer pack and 72.5 percent puree (Table 7-4).

Table 7-4. Distribution of the Final Product and Net Return per Acre

Final Product Distribution Freezer Pack %	Puree %	Net Return Per Acre
80	20	3,347.02
70	30	3,077.02
60	40	2,807.02
50	50	2,537.02
40	60	2,267.02
30	70	1,997.02
20	80	1,727.02
10	90	1,457.02
0	100	1,926.20*

Price structure is based on $.45 per pound for freezer pack and $.30 per pound for puree. System costs are based on a 20 acre enterprise, harvest rate of 3.5 hours per acre with a harvest yield of 10 tons per acre.

*The ownership cost is limited to only the processing equipment needed to process the fruit product into puree.

7.4.1 Product Distribution Ratio

The limiting factor in determining the percent of the raw fruit product to be processed as freezer pack is dependent on the uniform ripening of the field crop. Realistically, based on the present strawberry plant variety used in this cultural technique, the maximum percent of the field product acceptable for processing as freezer pack is not likely to be greater than 50 percent for the season's average.

7.4.2 Variance in Processing Equipment Ownership Costs

Table 7-5 was constructed to compare the annual fixed costs for the two processing equipment sets required to process the raw fruit product into the desired final product. The table shows the annual fixed equipment cost to be $1,565.55 for the equipment needed to process the raw product as puree and $12,621.00 per year for the equipment needed to process the raw product as freezer pack and puree. The annual fixed cost difference between the two processing methods is $11,055.45.

Table 7-5. Comparison of the Annual Processing Equipment Fixed Cost for the Two Processing Equipment Sets.

Item	100% Puree	Split Final Product
Dump Tank	$ 177.00	$ 177.00
Finishers	698.25	698.25
All Conveyors	690.30	1,380.60
Singulator		1,416.00
Decappers		7,980.00
Sizer		470.40
Slicer		498.75
Total Annual Fixed Cost	$1,565.55	$12,621.00

Therefore, it is for this reason that for the final product, when processing the raw product as freezer pack and puree, the percent of raw product processed as freezer pack be large enough to offset the increased equipment ownership costs.

7.5 Summary

The sensitivity analysis for the model showed that the model could be used as a fast and effective means for the strawberry enterprise manager to examine the efficiency and compatibility of the strawberry production system. The manager can change the field production costs, equipment costs and the final product distribution ratio to observe under which circumstances the enterprise is capable of providing the greatest cash return to the strawberry production system.

CHAPTER VIII

SUMMARY AND CONCLUSIONS

8.1 Summary

A computer model has been developed to examine the economic feasibility of mechanical harvesting and processing of solid-set culture strawberry production in Michigan. The current cultural practices for the solid-set strawberry production have been discussed with emphasis placed on the crucial factors which result in a high recovery rate by the harvester. A physical description and the operational performances for the mechanical harvester and the processing equipment were also discussed.

The model uses the traditional fixed and variable cost analysis method to establish the equipment ownership and operating costs. However, whenever possible custom hire rates are used by the model as a means for establishing a fair machine cost value to the strawberry enterprise. All costs in the model are charged exclusively to the strawberry enterprise and not spread out over the complete farming system which may incorporate other farm enterprises.

The model calculates the net cash return per acre to the strawberry enterprise but this does not include the land value. The land cost value, either land ownership or land rent costs were omitted from the model due to the great fluctuation in land values throughout the state of Michigan. Therefore the model was designed to show only the estimated net cash return per acre to the enterprise. Consequently, the user must subtract their land ownership cost or land rent cost from the model's estimated net cash return to obtain their predicted net cash return.

The model can be used as a budgeting tool to estimate the establishment and production costs for a solid-set culture strawberry production system. Even though the model has been validated, it only provides guidelines for the user. The users may need to adjust the values within the model to more accurately simulate their individual enterprise.

Since the model was designed to function interactively with the user, and for the user's convenience, the input and output data for this model are expressed in their common English units, i.e., acres, tons, pounds.

8.2 Conclusions

8.2.1. Harvester and Processing

Harvester and processing equipment data were collected during the 1983 harvest season for the purpose of examining the machine capacities and efficiencies. Based on that season's data the following conclusions were made:

1. Results showed the mechanical harvester to have a harvest recovery range from 85 to 98 percent with the season's average recovery rate being 92 percent.
2. The effective field capacity (EFC) for the harvester was 3.5 hours per acre (8.65 hours per ha) with a projected harvest

rate potential of 3 hours per acre (7.4 hours per ha) when equipped with the bulk material handling system.

3. The singulator averaged 5414 lbs per hour (2456 kg per hour) for the season with a 35 percent improvement in the separation of single berries and a 68 percent improvement in the separation of berry clusters.
4. The MSU-CML strawberry decapper averaged 2679 lbs per hour (1215 kg per hour) for the season with a discharge rate of 20% roll backs, 20% roll overs, 37% cut fruit, and 23% trash material.
5. Analysis of the decapper trash showed that 46 to 60% of the trash material was berry flesh. To decrease this berry flesh waste, the management may choose to route the decapped berry caps to the finisher for processing as puree and/or adjust the knife blade closer to the rollers to decrease the berry flesh loss to the trash bin.

8.2.2 Model

A systems approach was used to evaluate the economic feasibility of mechanical harvesting and processing of solid-set culture strawberry production. The computer model was validated with grower documentation to estimate the strawberry production system costs and net returns. As a result, the model indicates a potential for mechanical harvesting and processing of solid-set culture strawberry production in Michigan. The following conclusions were made:

1. Using the required field machinery and processing equipment set necessary for processing the complete fruit product as puree,

valued at 30 cents per pound, the break even acreage was estimated to be approximately 6.0 acres (2.4 ha). The average annual net profits would increase from $31.32 per acre at 6.0 acres (2.4 ha) to $2189.57 per acre at 40 acres (16.2 ha).

2. Yields and the price structure for the final product has a direct effect on the equal cost acres for the mechanical harvesting and processing system. Based on the production costs for a 20 acre (8.1 ha) strawberry enterprise, the results show a negative cash return would occur at yield levels less than 12.5 tons per acre (11.3 tonne per ha) for the final product puree value of 15 cents per pound (0.454 kg) as well as a negative cash return for the yield level of 5 tons per acre (4.5 tonne per ha) up to 30 cents per pound (kg) for the final product puree value.

3. Yield changes have a direct effect on the equal cost acreage (hectare) for the mechanical harvesting and processing system. The approximate equal cost acreage for a yield of 7 tons (6.3 tonne) was 19 acres (7.7 ha), which increases to 27 acres (10.9 ha) when the yields are 5 tons (4.5 tonne) but declines to 6 acres (2.4 ha) if the yields go to 10 tons (9.1 tonne), and to 4.7 acres (1.9 ha) if yields are 12 tons (10.9 tonne).

4. To obtain the economic advantage of purchasing the required processing equipment needed to process the final product as freezer pack and puree, the final product distribution would be 21 percent freezer pack and 79 percent puree when compared to that of processing the entire field product as 100 percent puree for a final product price structure of 40 cents per pound

(0.454 kg) for freezer pack and 20 cents per pound (0.454 kg) for puree. However, when the final product price structure increases to 45 cents and 30 cents per pound (kg) for freezer pack and puree respectively, the break even ratio would be increased to 27.5 percent freezer pack and 72.5 percent puree.

5. Elimination of the specialty equipment ownership cost to the growers.

The greatest annual cost to this production system is the ownership cost for the harvester and the processing equipment. However, should the grower be able to lease his machine out to other growers as a custom hire service, this would provide increased revenue to the machine owner and decrease the ownership cost per unit of land area. The custom service would benefit both the machine owner-operator as well as the grower employing the custom hire service.

Another possibility to eliminate the specialty equipment ownership cost to the growers would be that since the harvester and the processing equipment are specialty equipment of great initial investment, possibly the equipment manufacturers or the purchasers of the final product could own and operate the harvester and the processing equipment and contract with the growers to grow the strawberry crop. This would decrease the equipment ownership costs for the growers and at the same time decrease the equipment ownership cost per ton (tonne) of product harvested and processed as well as insuring themselves of the desired quantity (distribution of the final product) and quality of the final fruit product. This would decrease the storage cost of unneeded fruit product and insure a smooth and even flow of the strawberry product onto the market thus avoiding a large surge (glut) of the strawberry product onto the market.

8.3 Recommendations for Further Research

1. There is a need to determine the optimum strawberry transplant density for this cultural practice.
2. Further development in strawberry plant varieties which are favorable for mechanical harvesting and processing with emphasis in the following areas:
   a) varieties with different crop ripening dates (degree days)
   b) uniform ripening of the berry clusters.
3. Design a plant growth model to predict the harvest date.
4. To develop a mechanical - electronic fruit color sorter to compensate for the labor shortage and to alleviate the tedious hand sorting of the less desirable berries.
5. To incorporate into the model the option of using the cash flow cost analysis method to examine the system's cash flow sequence.

APPENDICES

APPENDIX 1

The data in this Appendix were used for the statistical analysis of the plant crown density count. The method of data collection is described in section 3.5.1 and the data analysis is discussed in Section 3.5.2. Columns C1, C2 and C3 represent the transplant spacing of the test plot in which the data were collected from, 91 x 61 cm, 61 x 61 cm, and 46 x 61 cm respectively. A total of 104 field samples were collected during this harvest season, 48 samples in C1, 44 samples in C2, and 12 samples in C3.

Also included in this appendix is a histogram of the samples for each of the transplant spacings. The histogram graphically illustrates the range and the number of strawberry plants counted per each unit area sample.

Table 1. Field data recorded by sample number for each of the three transplant spacings. Each number represents the number of plants found in 0.19 m^2 (2.0 ft^2).

C1= COLUMN 1 DATA= PLANT SPACING OF 91 x 61 CM (36 x 24 IN).
C2= COLUMN 2 DATA= PLANT SPACING OF 61 x 61 CM (24 x 24 IN).
C3= COLUMN 3 DATA= PLANT SPACING OF 46 x 61 CM (18 x 24 IN).

SAMPLE NUMBER	C1	C2	C3
1	13.	25.	15.
2	18.	31.	15.
3	24.	28.	15.
4	25.	24.	19.
5	17.	24.	20.
6	20.	21.	19.
7	26.	19.	18.
8	25.	21.	12.
9	16.	21.	17.
10	25.	22.	15.
11	18.	31.	12.
12	11.	22.	19.
13	24.	22.	
14	14.	20.	
15	24.	34.	
16	25.	26.	
17	21.	37.	
18	23.	35.	
19	25.	30.	
20	19.	23.	
21	18.	33.	
22	23.	18.	
23	29.	28.	
24	21.	29.	
25	29.	23.	
26	24.	25.	
27	23.	26.	
28	24.	27.	
29	16.	24.	
30	23.	22.	
31	18.	29.	
32	16.	18.	
33	13.	20.	
34	13.	25.	
35	14.	23.	
36	15.	26.	
37	14.	31.	
38	20.	32.	
39	17.	32.	
40	18.	27.	

Table 1. (continued)

SAMPLE NUMBER	C1	C2	C3
41	20.	25.	
42	9.	30.	
43	16.	32.	
44	7.	12.	
45	14.		
46	11.		
47	13.		
48	14.		

Table 2. Number of crown density observations in each of the transplant spacings.

Plant spacing of 91 x 61 cm (36 x 24 in).

MIDDLE OF INTERVAL[1]	NUMBER OF OBSERVATIONS	
6.	0	
8.	1	*
10.	1	*
12.	2	**
14.	9	*********
16.	5	*****
18.	7	*******
20.	4	****
22.	2	**
24.	9	*********
26.	6	******
28.	0	
30.	2	**

Plant spacing of 61 x 61 cm (36 x 24 in).

MIDDLE OF INTERVAL[1]	NUMBER OF OBSERVATIONS	
12.	1	*
14.	0	
16.	0	
18.	2	**
20.	3	***
22.	7	*******
24.	6	******
26.	7	*******
28.	4	****
30.	4	****
32.	6	******
34.	2	**
36.	1	*
38.	1	*

Table 2. (continued)

Plant spacing of 46 x 61 cm (18 x 24 in).

MIDDLE OF INTERVAL[1]	NUMBER OF OBSERVATIONS	
12.	2	**
13.	0	
14.	0	
15.	4	****
16.	0	
17.	1	*
18.	1	*
19.	3	***
20.	1	*

[1] Is the midpoint for each interval range in which the 'number of observations' fall.

APPENDIX 2

FIELD DATA SUMMARY

This appendix is a summary of the field data samples. This information was used for determining the harvester recovery rate and for the plant density count. The information is recorded by calendar date, sample number, and by the original transplant spacing.

Table A1 lists the harvest data for the harvester which preceded the harvester described in Chapter IV. Tables A2 and A3 list the harvest data for the harvester described in Chapter IV.

These samples were taken in pairs, one before and one after the harvester. The first sample collection was taken prior to harvesting. Three items of information were collected by this sample and recorded in columns A, B, and C. Column A contains the mass per unit area in grams of all the berries hand picked within the 0.19 m^2 (2 ft^2) square frame. The number on the left in this column is the mass of all the berries (green non-ripe, ripe, and overripe) in the sample and the number on the right is the mass of only the red ripe berries within the sample. Column B contains the plant density count per unit area for each of the samples. Column C contains the plant foilage height at the location of the sample collection.

The second sample collection was taken after the harvester had passed. This sample was taken in approximately the same location as the first sample but not the exact same location. Two items of information were collected at this sample and recorded in columns D and E. Column D contains the mass per unit area in grams of all the berries and berry flesh missed by the harvester within the 0.19 m^2 (2 ft^2) square frame. The number on the left in this column is the mass of all the berries and berry flesh missed by the harvester and the number on the right is the mass of only the red berries and red berry flesh missed by the harvester. Column E contains a second plant density count.

The last column, Column F, lists the percent recovery by the harvester for each of the samples. Once again, the number on the left corresponds to the all fruit category and the number on the right to the red ripe fruit category.

Table A1. Field Data Summary
Plant Spacing 91 x 61 cm (36 x 24 inches)

		A		B	C		D		E	F	
		Hand Picked Mass/Area (g)					Machine Loss Mass/Area (g)			Percent Recovery	
Date 1983	Sample Number	All	Red	Crown Density	Foilage Ht. cm	in.	All	Red	Crown Density	All	Red
July 3	101	757	324	18	22.9	9	69	16	16	91	95
July 3	102	699	280	13	25.4	10	142	38	13	80	86
July 3	103	623	338	14	27.9	11	191	109	15	69	68
July 4	104	624	131	14	22.9	9	154	73	20	75	44
July 4	105	720	282	17	25.4	10	254	115	18	65	59
July 4	106	512	198	20	25.4	10	69	29	9	86	85
July 4	107	828	404	16	20.3	8	84	36	7	90	91
July 4	108	742	524	14	15.2	6	103	59	11	86	89
July 4	109	652	440	13	17.9	7	331	185	14	49	58
July 5	110	810	493	13	17.9	7	95	50	18	88	90
July 5	111	833	488	24	35.6	14	109	21	25	87	95
July 5	112	999	658	17	25.4	10	143	63	20	85	90
July 5	113	861	592	26	25.4	10	71	61	25	92	89

Table A1 (continued)

Date 1983	Sample Number	A: Hand Picked Mass/Area (g) All	A: Hand Picked Mass/Area (g) Red	B: Crown Density	C: Foilage Ht. cm	C: Foilage Ht. in.	D: Machine Loss Mass/Area (g) All	D: Machine Loss Mass/Area (g) Red	E: Crown Density	F: Percent Recovery All	F: Percent Recovery Red
July 7	114	971	537	16	27.9	11	174	102	25	82	81
July 7	115	1072	515	18	25.4	10	125	63	11	88	88
July 7	116	1147	451	24	30.5	12	115	110	14	90	75
July 7	117	1164	622	24	30.5	12	162	81	25	86	87
July 10	118	888	567	21	30.5	12	74	39	23	91	93
July 10	119	816	653	25	20.3	8	96	77	19	88	88
July 10	120	698	607	18	20.3	8	150	138	23	78	77
July 10	121	982	702	29	33.0	13	134	92	21	86	87
July 10	122	885	718	29	30.5	12	237	98	24	73	86
July 10	123	727	543	23	25.4	10	116	71	24	84	87
July 12	124	790	602	16	30.5	12	137	113	23	83	81

Table A2. Field Data Summary
Plant Spacing 61 x 61 cm (24 x 24 inches)

		A		B	C		D		E	F	
		Hand Picked Mass/Area (g)					Machine Loss Mass/Area (g)			Percent Recovery	
Date 1983	Sample Number	All	Red	Crown Density	Foilage Ht. cm	in.	All	Red	Crown Density	All	Red
June 24	1	613	402	25	20.3	8	94	42	28	85	90
June 24	2	863	690	31	20.3	8	102	47	29	88	93
June 25	3	809	629	28	35.6	14	159	51	23	80	92
June 25	4	585	373	24	38.1	15	83	10	25	86	97
June 25	5	875	553	24	35.6	14	177	83	26	80	85
June 26	6	834	685	21	38.1	15	73	41	27	91	94
June 26	7	754	520	19	35.6	14	39	15	24	95	97
June 26	8	635	468	21	15.2	6	44	25	22	93	95
June 26	9	671	535	21	17.9	7	96	39	29	86	93
June 27	10	756	642	22	15.2	6	52	36	18	93	94
June 27	17	1230	1051	31	15.2	6	127	68	20	88	93
June 27	18	333	140	22	35.6	14	35	11	25	89	92

Table A2 (continued)

Date 1983	Sample Number	A Hand Picked Mass/Area (g) All	 Red	B Crown Density	C Foilage Ht. cm	 in.	D Machine Loss Mass/Area (g) All	 Red	E Crown Density	F Percent Recovery All	 Red
June 27	19	894	563	22	35.6	14	137	19	23	85	96
June 27	20	702	320	20	35.6	14	103	11	26	85	96
June 27	21	1142	993	34	22.9	9	142	28	31	88	97
June 27	22	1133	890	26	22.9	9	67	9	32	94	99
June 29	23	1064	490	37	33.0	13	254	60	32	76	88
June 29	24	1019	496	35	30.5	12	86	25	27	92	95
June 29	25	838	535	30	35.6	14	346	101	25	59	81
June 29	26	1202	521	23	38.1	15	160	41	30	87	92
June 29	27	968	453	33	33.0	13	185	52	32	81	88
June 29	28	1043	486	18	38.1	15	191	41	12	82	92
June 30	29	1134	672	21	38.1	15	206	61	20	82	91
June 30	30	1311	660	21	38.1	15	103	27	18	92	96
July 1	31	1130	469	24	27.9	11	61	14	29	95	97

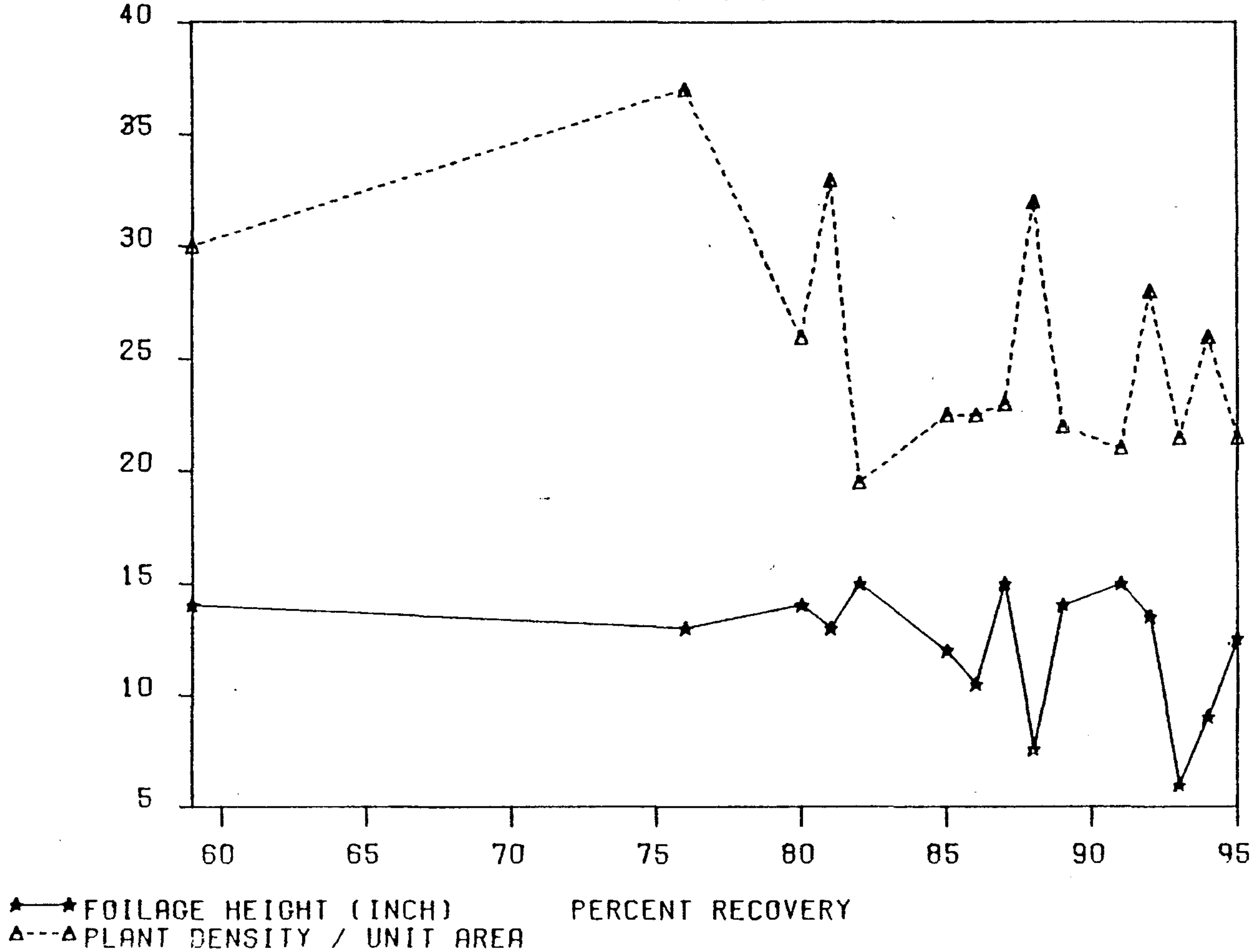
Table A3. Field Data Summary
Plant Spacing 46 x 61 cm (18 x 24 inches)

		A		B	C		D		E	F	
		Hand Picked Mass/Area (g)					Machine Loss Mass/Area (g)			Percent Recovery	
Date 1983	Sample Number	All	Red	Crown Density	Foilage Ht. cm	in.	All	Red	Crown Density	All	Red
June 26	11	860	580	15	30.5	12	123	57	18	86	90
June 26	12	983	664	15	25.4	10	101	55	12	90	92
June 26	13	910	641	15	35.6	14	240	96	17	74	85
June 26	14	790	551	19	35.6	14	155	46	15	80	92
June 26	15	680	408	20	43.2	17	150	40	12	78	90
June 26	16	539	329	19	43.2	17	132	50	19	76	85

A P P E N D I X 3

The following figure shows the negative relationship between plant density and plant foilage height to the percent recovery rate by the harvester. In other words, as plant density increases the foilage height tends to decrease. This is a normal function of plant growth in a dense plant population. This is due to the plant competition for the soil nutrients, water and available sun light to each plant in a dense environment. However, as the plant density and foilage height increase together, the percent recovery rate by the harvester also increases because the density of the crop and the height of the foilage assists the harvester recovery by suspending and supporting the fruit clusters up within the plant canopy. This facilitates the harvester by allowing the cutter bar to slide under the berry clusters before it severs the plant vine from the soil surface.

FOILAGE HEIGHT & PLANT DENSITY VS PERCENT RECOVERY
PLANT SPACING 61 X 61 CM (24 X 24 INCH)



APPENDIX 4

This appendix lists the recorded harvesting speeds during the 1983 season for the harvester described in Section 4.1. This information was used to determine the theoretical field capacity (TFC) and the field efficiency (FE) of the harvester.

The harvesting speeds increased as the operator became better acquainted with the machine and its controls.

General Comment

1 mile per hour = 88 feet per minute

88 feet per minute = 1.46 feet per second

Harvesting Speed

Test Number	Distance (ft)	Time (sec)	Miles per hr.
1	372	360	0.71
2	30	15	1.37
3	30	18	1.14
4	30	16	1.28
5	372	345	0.74
6	60	30	1.37
7	60	31	1.32
8	60	29	1.42
9	60	28	1.47
10	30	13	1.58

Theoretical Field Capacity

The theoretical field capacity is the rate of field coverage that would be obtained by the harvester if it were performing its function 100 percent of the time at the rated operating speed and always utilizing 100 percent of the time at the rated operating speed and always utilizing 100 percent of its rated cutter bar width. This maximum capacity is used as a basis for evaluating the performance of the harvester and its operator. TFC is calculated by multiplying the harvesting speed by the rated cutter bar width and dividing by a constant of 10 (8.25). This constant of 10(8.25) enables the calculation to be expressed in hectares per hour (acres per hour).

$$\text{TFC} = \frac{\text{Speed x Width}}{\text{Constant}}$$

Based on the season average harvesting speed of 1.24 miles per hour, the theoretical field capacity (TFC) was calculated to be 0.6 acre per hour (0.24 hectares per hour).

$$\text{TFC} = \frac{\text{Speed (mph) x width (ft)}}{\text{Constant}}$$

so,

$$\text{0.60 acre per hour} = \frac{\text{1.24 mph x 4 ft}}{8.25}$$

Effective Field Capacity

In 1983, the season's average effective field capacity (EFC) of the harvester was 0.30 acre per hour (0.12 hectare per hour). EFC is the actual rate of harvester performance, expressed in acres per hour (hectares per hour).

Field Efficiency

The average field efficiency (FE) of the harvester for this season was 50 percent. However, next year with a bulk handling system for the harvested fruit, the FE is expected to increase to approximately 80 percent. Field efficiency is the ratio of the harvester's EFC to its TFC. Field efficiency is calculated by dividing the harvester's EFC by its TFC and expressed as a percent.

$$FE = \frac{EFC}{TFC} \times 100$$

Once the operator can identify the production system's inefficiencies and correct for them, then the field efficiency and field capacity of the harvester can be increased. The factors which affect the harvester's field efficiency and field capacity are:

1) Skill and experience of the operator.
2) Crop and field conditions.
3) Proper operating speeds and adjustments of harvester components.
4) Ground speed of the machine.
5) Actual width of the header used.
6) Material handling system's capacity.

APPENDIX 5

ESTIMATED MAXIMUM ACREAGE PER HARVESTER PER PLANT VARIETY PER HARVEST SEASON

The maximum size of the strawberry enterprise in acreage is estimated by determining the effective field capacity (EFC) of the harvester, the length of the harvest season and the number of harvest hours per day. Based on the 1983 field data (Appendix 4) the season's average EFC for the harvester described in Section 4.1, the EFC was determined to be 0.30 acres per hour or in other words 3.5 hours per acre. Therefore, for the purpose of illustration three EFC's were used to estimate the maximum acreage (0.25, 0.30, and 0.34) with the assumption that the harvester would operate 12 hours per day and that with a moderate growing season the harvest season would last approximately eight days.

The assumption that the harvester would operate 12 hours per day is a realistic value for a short term time variant crop such as strawberries. Also from the experience of the 1983 season the ambient foliage moisture did not hinder the cutting and cleaning process of the raw fruit product by the harvester.

Therefore, based on the above assumptions the maximum size of the strawberry enterprise based on the three EFC's of 0.25, 0.30, and 0.34 acres per hour is estimated to be 24.0, 28.8, and 32.6 acres per year per harvester per strawberry plant variety, respectively.

These acreage values are only estimates which can be used to assist the potentially new and interested grower in estimating the size of a strawberry enterprise based on the 1983 harvest season date for the harvester described in Section 4.1.

A P P E N D I X 6

STRAWBERRY PRODUCTION MODEL

User Guide

I N T R O D U C T I O N

The strawberry production computer model is designed to assist researchers, extension agents, and growers alike who are interested in examining the solid set culture strawberry production system. The model was designed to be flexible in its parameters so that the values could be easily changed by the user. The flexibility of the model to change any of the preprogrammed values enables users to better simulate their present or projected future enterprise system without having to rewrite the computer program.

The output of the model is itemized by operation so that cost observations can be made regarding the system. The output of the model is presented in three parts: 1) field production costs, 2) machine and equipment costs, and 3) economic analysis. The economic analysis segment is a summary of the complete system's cost, product distribution, and product revenue minus the total cost to the strawberry enterprise.

How to Use the Model

The strawberry production model was designed to function interactively with the user. That is, the user simply types a command to the computer to start the program, immediately the program begins, and prompts the user with questions. This interactive technique enables the user with no previous computer experience to easily use this production model. Since the model was designed to function interactively with the user, and for the user's convenience, the input and output units for this model are expressed in their common English units, e.g., acres, tons, pounds.

Once the program begins, it will ask the user a total of 12 introductory questions. Following the user's response to the introductory questions the model will display in a menu table format the field production material prices and the application rates followed by the menu table for the specialty equipment, irrigation equipment, and the processing equipment. After each menu table the user is given the chance to change any of the values in the menu table to better simulate their individual enterprise.

To familiarize the user with the introductory questions and the menu tables displayed by the model, a sample copy of the model output has been attached.

<u>Initial Commands Needed to Start the Program</u>

(log in)

ATTACH, TAPE7, DATAFL1.	(return)
ATTACH, EWFILE, BERRY1.	(return)
HAL, LIB, UNSUP.	(return)
XFTN5.	(return)
LGO.	(return)

```
FOR THE FOLLOWING QUESTIONS - ENTER THE NUMERICAL VALUE ONLY.

WHAT IS THE SIZE OF THE STRAWBERRY ENTERPRISE IN ACRES ?10
WHAT IS THE WAGE RATE FOR THE OPERATOR ($/HR) ?8
WHAT IS THE WAGE RATE FOR THE LABORERS ($/HR) ?5


WHAT IS THE INTEREST RATE AS A PERCENT FOR THE:
FIELD MACHINERY ?14
PROCESSING EQUIPMENT ?14
IRRIGATION EQUIPMENT ?14


WHAT IS THE DIESEL FUEL PRICE ($/GAL) ?1.20
WHAT IS THE PROJECTED FIELD YIELD PER ACRE (LBS/ACRE) ?20000
WHAT IS THE PROJECTED HARVESTER RECOVERY RATE (ENTER AS A PERCENT) ?92
WHAT IS THE PROJECTED HARVEST RATE (ACRES/HR) ?.29
WHAT IS THE EXPECTED IRRIGATION RATE, EXPRESSED AS ACRE INCHES PER YEAR ?6
WHICH VERSION OF THE MODEL OUTPUT DO YOU WISH TO RECEIVE ?
              1    FOR  THE CONDENSED VERSION
              2    FOR  THE COMPLFTE VERSION
ENTER THE SELECTION NUMBER :1


THE FOLLOWING VALUES HAVE BEEN ENTERED.  IF ANY OF
THE VALUES ARE INCORRECT ENTER THE CORRESPONDING
SELECTION NUMBER.  IF THEY ARE ALL CORRECT, ENTER
SELECTION NUMBER 13.

 1. ACRE SIZE OF STRAWBERRY ENTERPRISE:    10.
 2. OPERATOR WAGE RATE:                     8.00
 3. LABORER WAGE RATE:                      5.00
 4. SPECIALTY EQUIPMENT INTEREST RATE:     14.00
 5. PROCESSING EQUIP. INTEREST RATE:       14.00
 6. IRRIGATION EQUIP. INTEREST RATE:       14.00
 7. DIESEL FUEL PRICE PER GALLON:           1.20
 8. PROJECTED YIELD PER ACRE:           20000.00
 9. PROJECTED HARVEST RECOVERY:            92.00
10. PROJECTED HARVEST RATE:                  .29
11. ACRE INCHES APPLIED PER YEAR:           6.00
12. MODEL OUTPUT:          THE CONDENSED VERSION.
13. ALL VALUES CORRECT - NO CHANGES
```

```
ENTER THE SELECTION NUMBER  :13
THE VALUE YOU HAVE ENTERED IS:  13.
IS IT CORRECT ? (Y OR N)y


THIS FOLLOWING QUESTION CONCERNS THE DISTRIBUTION OF
THE FINAL PRODUCT - ENTER THE NUMERICAL VALUES ONLY.
CHOOSE ONE OF THE FOLLOWING OPTIONS.
1. DIVIDE THE PRODUCT BETWEEN FREEZER PACK AND PUREE
2. SELL ALL (100) OF THE FINAL PRODUCT AS PUREE

ENTER THE NUMBER OF YOUR SELECTION  :2
THE VALUE YOU HAVE ENTERED IS:  2.
IS IT CORRECT ? (Y OR N)y
ENTER THE SELLING PRICE FOR PUREE ($/LB):.30
THE VALUE YOU HAVE ENTERED IS:  .3
IS IT CORRECT ? (Y OR N)y


**************************************************
                FIELD PRODUCTION
               MATERIAL DATA TABLE
**************************************************
```

MATERIALS		COST/UNIT	QUANTITY/ACRE	
OATS	*	2.00 / BU	2.00	BU/ACR
FERTILIZER(12-12-12)	*	174.00 / TON	.25	TON/AC
NITROGEN	*	136.00 / TON	50.00	LBS/AC
FUMIGATION	*	400.00 / CUSAPP	.00	-
STRAWBERRY PLANTS	*	61.00 / 1000	10890.00	PLANTS

```
DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N)n
```

****

FIELD PRODUCTION
CHEMICAL DATA TABLE

****

CHEMICALS	COST/UNIT	QUANTITY/ACRE
CAPTAN	1.10 / LB	5.00 LBS/AC
BENLATE	11.00 / LB	1.00 LBS/AC
RONALIN	16.80 / LB	1.50 LBS/AC
SINBAR	16.90 / LB	.50 LBS/AC
THIODAN	3.85 / LB	2.00 LBS/AC

DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N)n

****

CUSTOM RATES
DATA TABLE

****

OPERATION	RATE ($/ACRE)
PLOW	11.55
DISK	7.85
CULTIMULCH	5.60
DRILLING	5.90
SPRAYING	
GROUND RIG	4.00
AERIAL	4.90

DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N)n

SPECIALTY EQUIPMENT
DATA TABLE

ITEM	INITIAL COST	QUANTITY	MACHINE LIFE	INTEREST RATE	T.I.S.	R&M OF I.C.
TRACTOR	15000.00	1.00	15.00	14.00	.01	.00010
FORKLIFT ATTACHMENT	1300.00	1.00	15.00	14.00	.01	.00020
TRANSPLANTER (2 ROW)	1150.00	1.00	15.00	14.00	.01	.00075
FIELD ROLLER	1000.00	1.00	10.00	14.00	.01	.00040
HARVESTER	70000.00	1.00	10.00	14.00	.01	.00025
PALLET BOXES	20.00	80.00	10.00	14.00	.01	.01000

DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N)n

IRRIGATION EQUIPMENT
DATA TABLE

ITEM	INITIAL COST
PUMP	4500.00
PIPES & SPRINKLER	17600.00

DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N)n

PROCESSING EQUIPMENT
DATA TABLE

ITEM	INITIAL COST	QUANTITY
DUMP TANK	1000.00	1.00
FINISHERS	3500.00	1.00
ALL CONVEYORS	1300.00	3.00

DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N)n

SPECIALITY EQUIPMENT
FIXED AND OPERATIONAL COST TABLE

ITEM	FIXED COST/YEAR	FIXED COST/ACR	OPERATING COST/ACRE	TOTAL COST/ACRE
TRACTOR	2205.00	220.50	11.56	232.06
FORKLIFT ATTACHMENT	191.10	19.11	40.77	59.88
TRANSPLANTER (2 ROW)	169.05	16.91	64.85	81.76
FIELD ROLLER	177.00	17.70	3.63	21.33
HARVESTER	12390.00	1239.00	140.21	1379.21
PALLET BOXES	283.20	28.32	1.60	29.92

IRRIGATION EQUIPMENT
FIXED AND OPERATIONAL COST TABLE

ITEM	FIXED COST/YEAR	FIXED COST/ACR	OPERATING COST/ACRE	TOTAL COST/ACRE
PUMP	661.50	66.15	111.43	177.58
PIPES & SPRINKLER	2306.30	205.92	.00	205.92

PROCESSING EQUIPMENT
FIXED COST TABLE

ITEM	FIXED COST/YEAR	FIXED COST/ACRE
DUMP TANK	177.00	17.70
FINISHERS	698.25	69.83
ALL CONVEYORS	690.30	69.03

PROCESSING PLANT VARIABLE COST

REPAIR AND MAINTENANCE	GENERAL EXPENSE	PROCESS HOURS	LABOR COST	COST PER YEAR	$ PER LB
252.00	9200.00	30.7	1380.00	10832.00	.06

PROCESSING VARIABLE COST PER ACRE 1083.20

SUMMARY TABLE
FIELD PRODUCTION COST

****

	$/YEAR	$/ACRE
FALL	4784.00	478.40
YEAR 1	11199.72	1119.97
YEAR 2	3888.54	388.85
YEAR 3	3888.54	388.85
YEAR 4	4845.34	403.78
YEAR 5	16045.06	1337.09
YEAR 6	16045.06	1337.09
YEAR 7	16045.06	1337.09
YEAR 8	16045.06	1337.09
YEAR 9	16045.06	1337.09
TEN YEAR AVERAGE	9278.64	812.82

****

ECONOMIC ANALYSIS
-- PRODUCTION, MACHINE HARVEST AND PROCESS --

****

FIELD PRODUCTION COST PER ACRE	812.82
FIXED FIELD & IRR. EQUIP. COST PER ACRE	1813.61

HARVEST COST PER ACRE 286.14

FIXED PROCESSING COST PER ACRE 156.56

TOTAL AVAILABLE RAW PRODUCT PER ACRE (#/ACRE) 20000.0

HARVESTER RECOVERY EFFICIENCY 92.

QUANTITY DELIVERED TO PROCESSING PLANT, LB/ACRE 18400.0

PROCESSING COST PER ACRE (.059/LB) 1083.20

TOTAL COST PER ACRE 4152.32

==

REVENUE ($/ACRE) FOR MACHINE HARVEST AND PROCESS

TOTAL PRODUCT FOR PROCESSING 18400. LB.

USABLE PRODUCT FOR PROCESSING 16560. LB.

DISTRIBUTION OF PRODUCT FREEZER PACK = 0. PUREE = 100.

FREEZER PACK REVENUE $ .00

PUREE REVENUE $ 4968.00

TOTAL REVENUE ($/ACRE) $ 4968.00

****

REVENUE MINUS COSTS ($/ACRE) $ 815.68

APPENDIX 7

STAWBERRY PRODUCTION COMPUTER MODEL

This appendix contains the computer model (BERRY1) followed by the data file (DATAFL1) on page 165. The data file 'DATAFL1' contains the 1983-84 production costs, material application rates, and the number of each machine and its purchase value.

```
      PROGRAM BERRY1 (INPUT,OUTPUT,TAPE5=INPUT,TAPE6=OUTPUT,
     +TAPE7)
C
      INTEGER NSELECT,OPTION,OUTPUT
      REAL ACRES, ACRIN, FPPRICE, FREEZE, FUEL, HRVREC
      REAL LABWAGE, NEWVAL, OPWAGE,   PPRICE, PUREE, YPA
      REAL IRRINT,PROCINT,SPECINT
      CHARACTER*1 ANS
C
C     MODEL GENERAL INFORMATION QUESTIONS ARE ASKED FOR IN THIS SECTION
C
1     WRITE (6,'(///)')
      WRITE (6,*) 'FOR THE FOLLOWING QUESTIONS - ENTER THE NUMERICAL VAL
     +UE ONLY.'
      WRITE (6,*)
      WRITE (6,*) 'WHAT IS THE SIZE OF THE STRAWBERRY ENTERPRISE IN ACRE
     +S ?  '
      READ (5,*) ACRES
      WRITE (6,*) 'WHAT IS THE WAGE RATE FOR THE OPERATOR ($/HR) ?  '
      READ (5,*) OPWAGE
      WRITE (6,*) 'WHAT IS THE WAGE RATE FOR THE LABORERS ($/HR) ?  '
      READ (5,*) LABWAGE
      WRITE(6,'(/)')
      WRITE (6,*) 'WHAT IS THE INTEREST RATE AS A PERCENT FOR THE:'
      WRITE (6,*) 'FIELD MACHINERY ?  '
      READ (5,*) SPECINT
      WRITE (6,*) 'PROCESSING EQUIPMENT ?  '
      READ (5,*) PROCINT
      WRITE (6,*) 'IRRIGATION EQUIPMENT ?  '
      READ (5,*) IRRINT
      WRITE(6,'(/)')
      WRITE (6,*) 'WHAT IS THE DIESEL FUEL PRICE ($/GAL) ?  '
      READ (5,*) FUEL
      WRITE(6,*) 'WHAT IS THE PROJECTED FIELD YIELD PER ACRE (LBS/ACRE)
     +?  '
      READ (5,*) YPA
      WRITE (6,*) 'WHAT IS THE PROJECTED HARVESTER RECOVERY RATE (ENTER
     +AS A PERCENT) ?  '
      READ (5,*) HRVREC
      WRITE (6,*) 'WHAT IS THE PROJECTED HARVEST RATE (ACRES/HR) ?  '
      READ (5,*) HRVRAT
      WRITE (6,*) 'WHAT IS THE EXPECTED IRRIGATION RATE, EXPRESSED AS AC
     +RE INCHES PER YEAR ?  '
      READ (5,*) ACRIN
      WRITE(6,*)'WHICH VERSION OF THE MODEL OUTPUT DO YOU WISH TO RECEIV
     +E ? '
      WRITE(6,*)'                1     FOR  THE CONDENSED VERSION'
      WRITE(6,*)'                2     FOR  THE COMPLETE VERSION'
      WRITE(6,*)'ENTER THE SELECTION NUMBER :  '
      READ(5,*) OUTPUT
C               ***********  CHECK INPUTTED VALUES  *************
C
5     WRITE(6,'(//)')
      WRITE (6,*) 'THE FOLLOWING VALUES HAVE BEEN ENTERED.  IF ANY OF'
      WRITE (6,*) 'THE VALUES ARE INCORRECT ENTER THE CORRESPONDING'
      WRITE (6,*) 'SELECTION NUMBER.  IF THEY ARE ALL CORRECT, ENTER'
      WRITE (6,*) 'SELECTION NUMBER 13.'
```

```
         WRITE (6,*)
         WRITE (6,10) ACRES
10       FORMAT ('  1. ACRE SIZE OF STRAWBERRY ENTERPRISE:    ',F3.0)
         WRITE (6,20) OPWAGE
20       FORMAT ('  2. OPERATOR WAGE RATE:                    ',F5.2)
         WRITE (6,30) LABWAGE
30       FORMAT ('  3. LABORER WAGE RATE:                     ',F5.2)
         WRITE (6,40) SPECINT
40       FORMAT ('  4. SPECIALTY EQUIPMENT INTEREST RATE:  ',F7.2)
         WRITE (6,50) PROCINT
50       FORMAT ('  5. PROCESSING EQUIP. INTEREST RATE:    ',F7.2)
         WRITE (6,60) IRRINT
60       FORMAT ('  6. IRRIGATION EQUIP. INTEREST RATE:    ',F7.2)
         WRITE (6,70) FUEL
70       FORMAT ('  7. DIESEL FUEL PRICE PER GALLON:          ',F5.2)
         WRITE (6,80) YPA
80       FORMAT ('  8. PROJECTED YIELD PER ACRE:          ',F9.2)
         WRITE (6,90) HRVREC
90       FORMAT ('  9. PROJECTED HARVEST RECOVERY:           ',F6.2)
         WRITE (6,100) HRVRAT
100      FORMAT (' 10. PROJECTED HARVEST RATE:                ',F5.2)
         WRITE (6,110) ACRIN
110      FORMAT (' 11. ACRE INCHES APPLIED PER YEAR:          ',F5.2)
         IF (OUTPUT.EQ.1) THEN
             WRITE(6,*)'12. MODEL OUTPUT:          THE CONDENSED VERSION.'
         ELSE
             WRITE(6,*)'12. MODEL OUTPUT:          THE COMPLETE VERSION.'
         ENDIF
         WRITE (6,120)
120      FORMAT (' 13. ALL VALUES CORRECT - NO CHANGES')
         WRITE (6,*)
         WRITE (6,*)
130      WRITE (6,*)
         WRITE (6,*) 'ENTER THE SELECTION NUMBER  :    '
         READ (5,*) NSELECT
         VAL=REAL(NSELECT)
         CALL CHECKIT(VAL)
         NSELECT=INT(VAL)
         IF((NSELECT.LT.13).AND.(NSELECT.GT.0)) THEN
         IF (NSELECT .LE. 6) THEN
               IF (NSELECT.EQ.1) THEN
         WRITE(6,*)' INPUT THE NEW ACRE SIZE OF THE STRAWBERRY ENTERPRISE :
        + '
         ELSEIF (NSELECT.EQ.2) THEN
         WRITE(6,*)' INPUT THE NEW OPERATOR WAGE RATE: '
         ELSEIF (NSELECT.EQ.3) THEN
         WRITE(6,*)' INPUT THE NEW LABOR WAGE RATE: '
         ELSEIF (NSELECT.EQ.4) THEN
         WRITE(6,*)' INPUT THE NEW SPECIALTY EQUIPMENT INTEREST RATE: '
         ELSEIF (NSELECT.EQ.5) THEN
         WRITE(6,*)' INPUT THE NEW PROCESSING EQUIPMENT INTEREST RATE: '
         ELSE
         WRITE(6,*)' INPUT THE NEW IRRIGATION EQUIPMENT INTEREST RATE: '
         ENDIF
         ELSEIF (NSELECT.EQ.7) THEN
         WRITE(6,*)' INPUT THE NEW DIESEL FUEL PRICE PER GALLON: '
         ELSEIF (NSELECT.EQ.8) THEN
         WRITE(6,*)' INPUT THE NEW PROJECTED FIELD YIELD PER ACRE: '
```

```
      ELSEIF (NSELECT.EQ.9) THEN
      WRITE(6,*)' INPUT THE NEW PROJECTED HARVESTER RECOVERY RATE: '
      WRITE(6,*)' (ENTER AS A PERCENT) '
      ELSEIF (NSELECT.EQ.10.) THEN
      WRITE(6,*)' INPUT THE NEW PROJECTED HARVEST RATE: (ACRES/HR) : '
      ELSEIF (NSELECT.EQ.11.) THEN
      WRITE(6,*)' INPUT THE EXPECTED IRRIGATION RATE '
      WRITE(6,*)' (EXPRESSED AS ACRE INCHES PER YEAR) : '
      ELSE
      WRITE(6,*)'  ENTER: 1 - FOR THE CONDENSED OUTPUT '
      WRITE(6,*)'  ENTER: 2 - FOR THE COMPLETE OUTPUT '
      ENDIF
      READ (5,*) NEWVAL
      CALL CHECKIT(NEWVAL)
      IF (NSELECT .LE. 6) THEN
            IF (NSELECT.EQ.1) THEN
                  ACRES=NEWVAL
      ELSEIF (NSELECT.EQ.2) THEN
                  OPWAGE=NEWVAL
      ELSEIF (NSELECT.EQ.3) THEN
                  LABWAGE=NEWVAL
      ELSEIF (NSELECT.EQ.4) THEN
                  SPECINT=NEWVAL
      ELSEIF (NSELECT.EQ.5) THEN
                  PROCINT=NEWVAL
      ELSE
                       IRRINT=NEWVAL
      ENDIF
      ELSEIF (NSELECT.EQ.7) THEN
                  FUEL=NEWVAL
      ELSEIF (NSELECT.EQ.8) THEN
                  YPA=NEWVAL
      ELSEIF (NSELECT.EQ.9) THEN
                  HRVREC=NEWVAL
      ELSEIF (NSELECT.EQ.10.) THEN
                  HRVRAT = NEWVAL
      ELSEIF (NSELECT.EQ.11.) THEN
                  ACRIN=NEWVAL
      ELSE
      OUTPUT=INT(NEWVAL)
      ENDIF



      WRITE (6,*) 'ARE THERE ANY OTHER CHANGES TO BE MADE (Y OR N) ?'
      CALL CHEKANS(NFLAG)
      IF (NFLAG.EQ.1) THEN
          GOTO 130
      ELSE
          GOTO 5
      ENDIF
      ENDIF
C
C           ***********  DISTRIBUTION OF FINAL PRODUCT ***********
C
      WRITE (6,*)
      WRITE (6,*)
      WRITE (6,*)
```

```
      WRITE (6,*) 'THIS FOLLOWING QUESTION CONCERNS THE DISTRIBUTION OF'
      WRITE (6,*) 'THE FINAL PRODUCT - ENTER THE NUMERICAL VALUES ONLY.'
      WRITE (6,*) 'CHOOSE ONE OF THE FOLLOWING OPTIONS.'
      WRITE (6,*) '1. DIVIDE THE PRODUCT BETWEEN FREEZER PACK AND PUREE'
      WRITE (6,*) '2. SELL ALL (100) OF THE FINAL PRODUCT AS PUREE'
      WRITE (6,*)
140   WRITE(6,*) 'ENTER THE NUMBER OF YOUR SELECTION  :
      READ (5,*) OPTION
      VAL=REAL (OPTION)
      CALL CHECKIT(VAL)
      OPTION=INT(VAL)
      IF ((OPTION.LE.2).AND.(OPTION.GE.1)) THEN
      IF (OPTION.EQ.1) THEN
          WRITE (6,*) 'ENTER THE PERCENT OF THE PRODUCT TO BE SOLD AS FR
     +EEZER PACK  (THE REMAINDER WILL GO TO PUREE)  '
          READ (5,*) FREEZE
      CALL CHECKIT(FREEZE)
          PUREE = 100 - FREEZE
          WRITE(6,*) 'ENTER THE SELLING PRICE FOR FREEZER PACK ($/LB) :
     + '
          READ (5,*) FPRICE
      CALL CHECKIT(FPRICE)
      ELSE
          PUREE = 100
          FREEZE= 0
          FPRICE= 0
      ENDIF
      WRITE (6,*) 'ENTER THE SELLING PRICE FOR PUREE ($/LB):   '
      READ (5,*) PPRICE
      CALL CHECKIT(PPRICE)
      ELSE
      WRITE (6,*) 'ERROR IN INPUT'
      GOTO 140
      ENDIF
C
C      PROCESS THE INFORMATION  AND DISPLAY TABLES
C
C
C     INITIALIZE THE DATA TABLES
      CALL FILLTAB
      CALL FIELDPD
      CALL CUSTRAT
      CALL SPECEQP(SPECINT)
      CALL IRRIEQP (ACRES ,IRRINT)
      CALL PROCEQP (OPTION,PROCINT)
      CALL SPECOST( ACRES, OPWAGE,FUEL,HRVRAT,LABWAGE)
      CALL IRRCOST ( ACRES,ACRIN)
      CALL PROCOST (ACRES,OPTION)
      CALL PVCOS(ACRES,HRVREC,LABWAGE,YPA,OPTION)
      CALL FPCOST (ACRES,LABWAGE,OUTPUT)
      CALL ECONAN(YPA,HRVRAT,HRVREC,FREEZE,FPRICE,PUREE,
     +            PPRICE,OPTION)
      WRITE(6,'(////)')
      WRITE(6,*)' WOULD YOU LIKE TO CALCULATE ANOTHER ECONOMIC ANALYSIS'
      WRITE(6,*)' (Y OR N) ? '
      CALL  CHEKANS(NFLAG)
      IF (NFLAG.EQ.1) GOTO 1
      STOP
```

```
      END
C     **************************************************************
C            **********   SUBROUTINE CHECKIT  ***********
C     **************************************************************
      SUBROUTINE CHECKIT (INDATA)
      REAL INDATA
10    WRITE (6,*) 'THE VALUE YOU HAVE ENTERED IS:   ',INDATA
      WRITE (6,*) 'IS IT CORRECT ? (Y OR N) '
      CALL CHEKANS(NFLAG)
      IF (NFLAG.EQ.O) THEN
      WRITE (6,*) 'ENTER THE CORRECT VALUE : '
      READ (5,*) INDATA
      GOTO 10
      ENDIF
      RETURN
      END
C      ****************************************************************
C             ***********   SUBROUTINE MENU CHANGE   ***********
C      ****************************************************************
      SUBROUTINE MENUCHG (ARY,SZ,CHGFLG,SEL)
      INTEGER SEL,SZ,CHGFLG
      CHARACTER*20 ARY(*)
      WRITE (6,*) 'WHICH ITEM DO YOU WISH TO CHANGE ? '
      LIMIT =SZ*2
      INDEX = 1
      DO 10 I=1,LIMIT,2
      LEN1 = LNB(ARY(I))
      WRITE (6,5) INDEX,ARY(I)(:LEN1),ARY(I+1)
5     FORMAT (I2,'. ',A,'  ',A)
      INDEX = INDEX + 1
10    CONTINUE
      IF (CHGFLG.EQ.1) THEN
      WRITE (6,*) INDEX,'. NO CHANGES    OR    DISPLAY TABLE.'
      ENDIF
      CHGFLG=O
      WRITE (6,*)
      WRITE (6,*)
12    WRITE (6,*) 'ENTER THE SELECTION NUMBER  :    '
15    READ (5,*) SEL
      IF ((SEL.LT.1).OR.(SEL.GT.INDEX)) THEN
          WRITE (6,*) ' INVALID INPUT '
          GO TO 12
      ELSE
          WRITE (6,*) ' THE SELECTION NUMBER YOU HAVE ENTERED IS
    +',SEL
          WRITE (6,*) ' IS IT CORRECT ? (Y OR N) '
20        CALL CHEKANS(NFLAG)
               IF (NFLAG.EQ.1) THEN
                  GO TO 30
               ELSE
                  GO TO 15
               ENDIF
30         IF (SEL.LT.INDEX) CHGFLG=1
      ENDIF
      RETURN
      END
C     ****************************************************************
C            **********   SUBROUTINE CHANGE TABLE   ***********
```

BERRY1 6

```
C     ***************************************************************
      SUBROUTINE CHGTAB (NROW,ROW,COL,ITEMNAM,ITEMHED,TABL)
      INTEGER ROW,COL,CHGFLG,HOLDROW
      REAL TABL (ROW,20),NEWVAL
      CHARACTER*20 ITEMNAM(*),ITEMHED(*),UNITS
      CHGFLG=1
C
C     ADJUST ROW DIMENSION IF INDICATED. HOWEVER
C     NROW=0 INDICATES FLAG FOR FIELD PRODUCTION
C     PROCESSING
      IF ((NROW.NE.ROW).AND.(NROW.NE.-1)) THEN
C      SAVE THE ORIGINAL ROW VALUE FOR LATER TABLE TRANSFER.
      HOLDROW = ROW
C      RESET ROW FOR CORRECT TABLE DISPLAY AND CHANGE OPTIONS
      ROW = NROW
      ENDIF
C
5     CALL MENUCHG (ITEMNAM,ROW,CHGFLG,INDXR)
      IF (CHGFLG.EQ.1) THEN
      CHGFLG=2
      CALL MENUCHG (ITEMHED,COL,CHGFLG,INDXC)
      IR=INDXR*2-1
      IC=INDXC*2-1
      LEN1=LNB(ITEMNAM(IR))
      LEN2=LNB(ITEMHED(IC))
      LEN3=LNB(ITEMHED(INDXC*2))
      WRITE (6,10) ITEMNAM(IR)(:LEN1),ITEMHED(IC)(:LEN2),
     +ITEMHED(INDXC*2)(:LEN3)
10    FORMAT (' ENTER THE NEW VALUE FOR ',A,' ',A,' ',A,' ')
      IF (INDXC.EQ.4) WRITE (*,*) ' ENTER AS A PERCENT.'
      READ (5,*) NEWVAL
      CALL CHECKIT (NEWVAL)
      TABL(INDXR,INDXC) = NEWVAL
      WRITE (6,*) 'ARE THERE ANY MORE CHANGES TO BE MADE (Y OR N) ? '
      CALL CHEKANS(NFLAG)
      IF (NFLAG.EQ.1) GOTO 5
      ENDIF
C     RESET ROW TO ORIGINAL VALUE FOR TABLE TRANSFER
      ROW = HOLDROW
      RETURN
      END
C     ***************************************************************
C            **********   SUBROUTINE  CHECK  ANSWER **********
C     ***************************************************************
      SUBROUTINE CHEKANS(NFLAG)
      INTEGER NFLAG
      CHARACTER*1 ANS
10    READ (5,'(A1)') ANS
      IF (ANS..EQ.'Y') THEN
         NFLAG=1
      ELSEIF (ANS.EQ.'N') THEN
         NFLAG=0
      ELSE
      WRITE (6,*) ' INVALID INPUT - ENTER Y OR N.'
      GOTO 10
      ENDIF
      RETURN
      END
```

```
C      ***************************************************************
C              ************  SUBROUTINE PRINT TABLE  ***********
C      ***************************************************************
       SUBROUTINE PRINTAB (TABLE,NROW,ROW,COL,ITEM,HEADING)
       INTEGER ROW,COL
       REAL TABLE(ROW,6)
       CHARACTER*20 ITEM(15),HEADING(12)
       LIMIT=COL*2
       WRITE(6,3)
3      FORMAT(' ',T22,'*')
       WRITE (6,4) (HEADING(J),J=1,LIMIT,2)
       WRITE (6,5) (HEADING(J),J=2,LIMIT,2)
4      FORMAT ('  ITEM',T22,'* ',A,T35,A,T44,A,T54,A,T64,A,T71,A)
5      FORMAT(  T22,'* ',A,T35,A,T44,A,T54,A,T64,A,T71,A)
       WRITE (6,*) '**********************',('**********',J=1,COL)
       INDEX=1
       DO 20 I=1,NROW
       WRITE (6,10) ITEM(INDEX),(TABLE (I,J),J=1,COL)
10     FORMAT (T2,A20,T22,'* ',5(F8.2,' '),F8.5)
       WRITE (6,*) '**********************',('**********',J=1,COL)
       INDEX=INDEX+2
20     CONTINUE
       RETURN
       END
C      ***************************************************************
C              ************  SUBROUTINE CUSTOM RATES  **********
C      ***************************************************************
       SUBROUTINE CUSTRAT
       INTEGER FLAG,ROW
       DIMENSION RATETAB(6,1)
       COMMON / CRDT / RATETAB
       CHARACTER*20 ITEM(12),HEADING(4)
       DATA (ITEM(I),I=1,12,2)/'PLOW','DISK','CULTIMULCH',
      +'DRILLING','GROUND RIG','AERIAL'/
       DATA  HEADING/'OPERATION',' ','RATE($/ACRE)',' '/
       ROW=6
       DO 5 I=2, ROW*2,2
5      ITEM(I) = '  '
       WRITE(6,'(//)')
       WRITE(6,*)'****************************************'
       WRITE(6,*)'                   CUSTOM RATES '
       WRITE(6,*)'                    DATA TABLE'
       WRITE(6,*)'****************************************'
100    WRITE (6,*) ' OPERATION                RATE ($/ACRE)'
       WRITE (6,*) '**********************************'
       DO 50  I=1,4
       INDEX = I*2 -1
         WRITE(6,7) ITEM(INDEX), RATETAB(I,1)
7        FORMAT(T2,A20,T22,'* ',F8.2)
       WRITE(6,75)
50     CONTINUE
       WRITE(6,8)
8      FORMAT(' SPRAYING')
       WRITE(6,9) ITEM(INDEX +2),RATETAB(5,1)
       WRITE(6,75)
75     FORMAT('**********************************')
       WRITE(6,9) ITEM(INDEX +4),RATETAB(6,1)
       WRITE(6,75)
```

```
9     FORMAT(T7,A20,T22,'= ',F8.2)
      WRITE(6,'(//)')
      WRITE(6,*)' DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N)'
      CALL CHEKANS(FLAG)
      IF  (FLAG.EQ.1) THEN
10    CALL CHGTAB (ROW,ROW,1,ITEM,HEADING,RATETAB)
      GO TO 100
      ENDIF
      RETURN
      END
C     ***********************************************************
C           ************   SUBROUTINE FIELD PRODUCTION  *********
C     ***********************************************************
      SUBROUTINE FIELDPD
      INTEGER FLAG,SELC,SELR,CHGFLG,MNO,CNO
      REAL MATCQ(5,2), CHEMCQ(5,2),SELECT,VAL,NEWVAL
      CHARACTER*6 MUNIT(5,2),CUNIT(5,2)
      CHARACTER*20 MITEM (10),CITEM(10),HEADING(4)
      COMMON / FPDT / MATCQ,CHEMCQ
      DATA MUNIT/'BU','TON','TON','CUSAPP','1000','BU/ACRE',
     +'TON/ACRE','LBS/ACRE',' - ','PLANTS/ACRE'/
      DATA CUNIT/5*'LB',5*'LBS/ACRE'/
      DATA (MITEM(I),I=1,10,2)/'OATS','FERTILIZER(12-12-12)','NITROGEN',
     +'FUMIGATION','STRAWBERRY PLANTS'/
      DATA (CITEM(I),I=1,10,2)/'CAPTAN','BENLATE','RONALIN','SINBAR',
     +'THIODAN'/
      DATA HEADING/' COST/UNIT',' ','QUANTITY/ACRE',' '/
      CNO=5
      MNO=5
C
C      FILL ARRAY WITH BLANK ENTERIES
C
      DO 3  I=2,MNO*2,2
          MITEM(I)='  '
3         CITEM(I)='  '
C
C           ************   DISPLAY PRODUCTION TABLE  ***********
C
      WRITE (6,'(//)')
      WRITE(6,*)'*****************************************************'
      WRITE(6,*)'                       FIELD  PRODUCTION'
      WRITE(6,*)'                      MATERIAL DATA TABLE'
      WRITE(6,*)'*****************************************************'
5     WRITE (6,10)
10    FORMAT('1MATERIALS',T29,'COST/UNIT',T44,'QUANTITY/ACRE')
      WRITE(6,*) '******************************************************
     +*******'
      DO 100 I=1,MNO
      WRITE(6,50) MITEM(2*I-1),MATCQ(I,1),MUNIT(I,1),MATCQ(I,2),
     +MUNIT(I,2)
50    FORMAT(' ',A20,T22,' = ',F7.2,' / ',A6,'  ',F8.2,'   ',A)
      WRITE(6,*) '******************************************************
     +*******'
100   CONTINUE
C
C             ***********  CHECK FOR CHANGES  *************
C
      WRITE(6,'(//)')
```

```
      WRITE(6,*)' DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N) '
      CALL CHEKANS(FLAG)
      IF(FLAG.EQ.1) THEN
      CALL CHGTAB(-1,MNO,2,MITEM,HEADING,MATCQ)
      GO TO 5
      ENDIF
C
C            ************* FIELD PRODUCTION CHEMICALS ***********
C
      WRITE(6,'(//)')
      WRITE(6,*)'****************************************************'
      WRITE(6,*)'                   FIELD  PRODUCTION'
      WRITE(6,*)'                  CHEMICAL DATA TABLE'
      WRITE(6,*)'****************************************************'
53    WRITE (6,55)
55    FORMAT (' ',' CHEMICALS',T27,'COST/UNIT',T44,'QUANTITY/ACRE')
      WRITE(6,*) '*****************************************************
     +********'
      DO 200 I=1,CNO
       WRITE (6,50) CITEM(2*I-1),CHEMCQ(I,1),CUNIT(I,1),
     +CHEMCQ(I,2),CUNIT(I,2)
      WRITE(6,*) '*****************************************************
     +********'
200   CONTINUE
C
C              ************ CHECK FOR CHANGES *************
C
      WRITE(6,'(//)')
      WRITE(6,*)' DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N) '
      CALL CHEKANS(FLAG)
      IF(FLAG.EQ.1) THEN
      CALL CHGTAB(-1,CNO,2,CITEM,HEADING,CHEMCQ)
      GO TO 53
      ENDIF
      RETURN
      END
C     ***************************************************************
C            ******* SUBROUTINE SPECIALITY EQUIPMENT ********
C     ***************************************************************
      SUBROUTINE SPECEQP(SPECINT)
      INTEGER FLAG,ROW,COL
      REAL SPECTAB (6,6)
      CHARACTER MACHINE*20 , HEADING*20
      DIMENSION HEADING(12)
      COMMON /SEDT/ SPECTAB
      COMMON / SPEC / MACHINE(12)
      DATA (MACHINE(I),I=1,12,2)/'TRACTOR','FORKLIFT ATTACHMENT',
     +'TRANSPLANTER (2 ROW)','FIELD ROLLER','HARVESTER','PALLET BOXES'/
      DATA HEADING/'INITIAL',' COST','QUANTITY',' ','MACHINE',
     +' LIFE','INTEREST',' RATE','T.I.S.',' ',' R&M',' OF I.C.'/
      COL=6
      ROW=6
      DO 10 I=2,ROW=2,2
10    MACHINE (I)=' '
      DO 15 J=1,ROW
15    SPECTAB(J,4)=SPECINT
C
C     FILL INTEREST RATE IN TABLE
```

```
C
20    WRITE(6,'(//)')
      WRITE(6,*)'**************************************************'
      WRITE(6,*)'               SPECIALTY  EQUIPMENT'
      WRITE(6,*)'                    DATA TABLE'
      WRITE(6,*)'**************************************************'
      CALL PRINTAB(SPECTAB,ROW,ROW,COL,MACHINE,HEADING)
      WRITE(6,'(//)')
      WRITE(6,*)' DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N) '
      CALL CHEKANS(FLAG)
      IF (FLAG.EQ.1) THEN
30    CALL CHGTAB (ROW,ROW,COL,MACHINE,HEADING,SPECTAB)
      GO TO 20
      ENDIF
      RETURN
      END
C     ***********************************************************'
C             *******   SUBROUTINE PROCESSING EQUIPMENT   *******
C     ***********************************************************
      SUBROUTINE PROCEOP( OPTION,PROCINT)
      INTEGER  OPTION,FLAG,ROW,COL
      CHARACTER*20 MACHINE(14),HEADING(4)
      COMMON / PEDT / PROCTAB(7,6)
      COMMON/PROCESS/MACHINE
      DATA (MACHINE(I),I=1,14,2)/'DUMP TANK','FINISHERS','ALL CONVEYORS
     +','SINGULATOR','DECAPPER','SIZER','SLICER'/
      DATA HEADING/'INITIAL',' COST','QUANTITY','   '/
      COL=2
      ROW=7
      IF (OPTION.EQ.2) THEN
        PROCTAB(3,2)=3.
        NROW=3
      ELSE
      PROCTAB(3,2)=6.0
      NROW=7
      ENDIF
C
C          -------- FILL  IN EVEN ENTRIES IN MACHINE --------
C
      DO 10 I=2,NROW*2,2
10    MACHINE(I)='  '
C
C     FILL INTEREST RATE IN TABLE
C
      DO 15 I=1,NROW
15        PROCTAB(I,4)=PROCINT
20    WRITE(6,'(//)')
      WRITE(6,*)'**************************************************'
      WRITE(6,*)'               PROCESSING EQUIPMENT'
      WRITE(6,*)'                    DATA TABLE'
      WRITE(6,*)'**************************************************'
      CALL PRINTAB(PROCTAB,NROW,ROW,COL,MACHINE,HEADING)
      WRITE(6,'(//)')
      WRITE(6,*)' DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N) '
      CALL CHEKANS(FLAG)
      IF (FLAG.EQ.1) THEN
         CALL CHGTAB (NROW,ROW,COL,MACHINE,HEADING,PROCTAB)
         GO TO  20
```

```
      ENDIF
      RETURN
      END
C     ***************************************************************
C             *******  SUBROUTINE IRRIGATION EQUIPMENT  ******
C     ***************************************************************
      SUBROUTINE IRRIEQP( ACRES ,IRRINT)
      INTEGER FLAG,CHGFLG,ROW,COL,INDXR
      REAL IRRTAB(2,6),ACRES ,NEWVAL,IRRINT
      COMMON / IEDT / IRRTAB
      CHARACTER*20 ITEM(4),HEADING(2)
      DATA ITEM/'PUMP',' ','PIPES & SPRINKLER',' '/
      DATA HEADING/'INITIAL',' COST'/
C
C           -------    CALCULATE INITIAL COST  -------
C
      IRRTAB(1,1)=ACRES * 450.
      IRRTAB(2,1)=ACRES * 1760.
      ROW=2
      COL=1
C
C     FILL IN INTEREST RATES IN TABLE
C
      DO 15 I=1,ROW
15        IRRTAB(I,4)=IRRINT
20    WRITE(6,'(//)')
      WRITE(6,*)'**************************************************'
      WRITE(6,*)'                IRRIGATION EQUIPMENT'
      WRITE(6,*)'                     DATA TABLE'
      WRITE(6,*)'**************************************************'
      CALL  PRINTAB (IRRTAB,ROW,ROW,COL,ITEM,HEADING)
      WRITE(6,'(//)')
      WRITE(6,*)' DO YOU WISH TO CHANGE ANY OF THESE VALUES ? (Y OR N) '
      CALL CHEKANS(FLAG)
      IF (FLAG.EQ.1) THEN
      CHGFLG=1
          CALL MENUCHG(ITEM,ROW,CHGFLG,INDXR)
          IF (CHGFLG.EQ.1) THEN
               WRITE (6,30)  ITEM(INDXR*2-1)
30             FORMAT (' ENTER THE NEW INITIAL VALUE FOR THE:  ',A)
               READ (5,*) NEWVAL
               CALL CHECKIT (NEWVAL)
          IRRTAB(INDXR,1)=NEWVAL
          ENDIF
          GO TO 20
      ENDIF
      RETURN
      END
C     ***************************************************************
C         *********  SPECIALITY EQUIPMENT COST  **********
C     ***************************************************************
      SUBROUTINE SPECOST (ACRES,OPWAGE,FUEL,HRVRAT,LABWAGE)
      CHARACTER*20 ITEM,HEADING(8)
      INTEGER ROW,OPNO,COL
      COMMON /SPEC/ ITEM(12)
      COMMON/CSTHEAD/HEADING
      REAL SV,SPECTAB(6,6),OPWAGE,LABR,LABWAGE,CST(6,4),RMCST(6)
      COMMON / SECT / CST
```

```
      COMMON /SEDT/ SPECTAB
C     CALCULATE FIXED COST PER YEAR
      ROW = 6
      SV=10.
      DO 10 I=1,ROW
           DP=( SPECTAB(I,1)-SPECTAB(I,1)*SV/100)/SPECTAB(I,3)
           TINT=( SPECTAB(I,1)+SPECTAB(I,1) * SV/100.)/2. *
     +SPECTAB(I,4)/100
           TTIS= 0.01 * SPECTAB(I,1)
           CST(I,1)=(DP + TINT + TTIS) * SPECTAB(I,2)
           CST(I,2)=CST(I,1)/ACRES
10    CONTINUE
C
C  ---------------- CALCULATE VARIABLE COST -----------------
C                      1.  CALCULATE REPAIR & MAINTENANCE
C
      DO 20 I=1,ROW
20    RMCST(I)=SPECTAB(I,1)*SPECTAB(I,6)
C
C                      2.  CALCULATE V.C. FOR TRACTOR
C
      LABR=1 * OPWAGE
      FUELCST=.043 * 40. * FUEL
      CST(1,3)=RMCST(1) + FUELCST + LABR
C
C                      3.  CALCULATE V.C. FOR FORKLIFT
C
      CST(2,3)=( RMCST(2) + CST(1,3))/HRVRAT
C
C                      4.  CALCULATE V.C. FOR TRANSPLATER
C
      LABR=4 * LABWAGE
      CST(3,3)=( RMCST(3) + LABR + CST(1,3))/0.5
C
C                      5.  CALCULATE V.C. FOR FIELD ROLLER
C
      CST(4,3)=( RMCST(4) + CST(1,3))/3.3
C
C                      6.  CALCULATE V.C. FOR  HARVESTER
C
      LABR=OPWAGE + (2* LABWAGE)
      FUELCST= 100. * .043 * FUEL
      CST(5,3)=( RMCST(5) + LABR + FUELCST) /HRVRAT
C
C                      7.  CALCULATE V.C. FOR PALLET BOXES
C
      CST(6,3)=RMCST(6)/ACRES
C
C    ADJUST VARIABLE COST TO REFLECT THE NUMBER OF MACHINES
C
      DO 30 I=1,ROW
30    CST(I,3)=CST(I,3) * SPECTAB(I,2)
C
C  ------------ CALCULATE TOTAL COST/ACRE ----------------
C
      DO 50 I=1,ROW
C   ADD FIXED COST/ACRE TO OPERATING COST/ACRE
50    CST(I,4)=CST(I,2) + CST(I,3)
```

```
C     ------------- DISPLAY  SPECIALITY EQUIPMENT COST TABLE ------
C
        DATA HEADING/' FIXED',' COST/YEAR',' FIXED',' COST/ACRE',
       +' OPERATING',' COST/ACRE',' TOTAL',' COST/ACRE'/
        ROW=6
        COL=4
        WRITE(6,'(//)')
        WRITE(6,*)'***************************************************'
        WRITE(6,*)'                SPECIALITY EQUIPMENT'
        WRITE(6,*)'         FIXED AND OPERATIONAL COST TABLE'
        WRITE(6,*)'***************************************************'
        CALL PRINTAB(CST,ROW,ROW,COL,ITEM,HEADING)
        RETURN
        END
C       ************************************************************
C              *********  SUBROUTINE IRRIGATION COST  ***********
C       ************************************************************
        SUBROUTINE IRRCOST ( ACRES,ACRIN)
        CHARACTER*20 ITEM(4),HEADING(8)
        INTEGER ROW,COL
        REAL SV,IRRTAB(2,6),CST(2,4),KWHRACR,KWHR
        COMMON / IECT / CST
        COMMON /IEDT/ IRRTAB
        COMMON/CSTHEAD/HEADING
        DATA ITEM/'PUMP',' ','PIPES & SPRINKLER',' '/
C
C     CALCULATE FIXED COST PER YEAR AND PER ACRE
C
        ROW=2
        SV=10.
        DO 10 I=1,ROW
            DP=( IRRTAB(I,1)-IRRTAB(I,1)*SV/100.)/IRRTAB(I,3)
            TINT=(IRRTAB(I,1)+IRRTAB(I,1)*SV/100.)/2. * IRRTAB(I,4)/100.
            TTIS=0.01 * IRRTAB(I,1)
            CST(I,1)=DP + TINT + TTIS
            CST(I,2)=CST(I,1)/ACRES
10      CONTINUE
C
C       CALCULATES THE 10 YEAR AVERAGE FIXED COST FOR
C       THE INCREASE IN THE PIPE & SPRINKLER SYSTEM.
C
        TEMP=CST(2,1)
        TEMP1=TEMP * 10.
        TEMP2=TEMP * .2 * 6.
        CST(2,1)=(TEMP1 + TEMP2)/10.
C
C
C       CALCULATE VARIABLE COST PER ACRE AND TOTAL COST PER ACRE
C
        APPRATE=.28
        KWHRACR=0.0
        KWHRACR=(0.746 * 5) * ACRES
        KWHR=0.1
        CST(1,3)=(ACRIN/APPRATE*KWHRACR*KWHR ) +(IRRTAB(1,6) *
       +IRRTAB(1,1)/ACRES)
        CST(1,4)=CST(1,2)+CST(1,3)
        CST(2,3)=0
        CST(2,4)=CST(2,2)
```

```
C
C    -------  DISPLAY IRRIGATION EQUIPMENT COST TABLE  -------
C
      COL=4
      WRITE(6,'(//)')
      WRITE(6,*)'***************************************************'
      WRITE(6,*)'              IRRIGATION EQUIPMENT'
      WRITE(6,*)'         FIXED AND OPERATIONAL COST TABLE'
      WRITE(6,*)'***************************************************'
      CALL PRINTAB(CST,ROW,ROW,COL,ITEM,HEADING)
C
      RETURN
      END
C     ***************************************************************
C          **********  PROCESSING FIXED COST TABLE  **********
C     ***************************************************************
      SUBROUTINE PROCOST( ACRES,OPTION)
      CHARACTER*20 ITEM(4),HEADING(8)
      INTEGER ROW,COL,OPTION
      REAL SV,PROCTAB(7,6),CST(7,4)
      COMMON / PECT / CST
      COMMON /PEDT/ PROCTAB
      COMMON/PROCESS/ITEM
      COMMON/CSTHEAD/HEADING
C  ------  CALCULATE FIXED COST PER YEAR AND PER ACRE ------
      ROW=7
      SV=10.
      IF (OPTION.EQ.2) THEN
         NROW=3
      ELSE
         NROW=ROW
      ENDIF
      DO 10 I=1,NROW
         DP=(PROCTAB(I,1)-PROCTAB(I,1)*SV/100.)/PROCTAB(I,3)
         TINT=(PROCTAB(I,1)+PROCTAB(I,1)*SV/100.)/2.*PROCTAB(I,4)/
     +              100.
         TTIS=0.01*PROCTAB(I,1)
         CST(I,1)=(DP+TINT+TTIS)*PROCTAB(I,2)
         CST(I,2)=CST(I,1)/ACRES
10    CONTINUE
C
C  ------  DISPLAY PROCESSING EQUIPMENT FIXED COST TABLE  ------
C
      COL=2
      WRITE(6,'(//)')
      WRITE(6,*)'***************************************************'
      WRITE(6,*)'              PROCESSING EQUIPMENT'
      WRITE(6,*)'                FIXED COST TABLE'
      WRITE(6,*)'***************************************************'
      CALL PRINTAB(CST,NROW,ROW,COL,ITEM,HEADING)
C
      RETURN
      END
C     ***************************************************************
C        *********  SUBROUTINE PROCESSING VARIABLE  COST  ********
C     ***************************************************************
      SUBROUTINE PVCOS (ACRES,HRVREC,LABWAGE,YPA,OPTION)
      REAL PROCTAB(7,5),LABWAGE,PVCPA,DPPP,TPRMC,PRMCPA
```

```
      INTEGER  OPTION
      COMMON /PEDT/ PROCTAB
      COMMON / TPVCST / PVCPA,DPPP
C
C     THE R&M COST FOR THE PROCESSING EQUIPMENT IS ESTIMATED ON
C      A PERCENT OF THE INITIAL COST OF  THE EQUIPMENT.
C     (3 PERCENT IS USED FOR THIS VALUE. --  PRMP)
C
C     GENERAL COST -- SUCH AS ELECTRICITY, WATER, BUILDING AND
C     FREEZER RENT AND ONE  FOREMAN ARE BASED ON A COST PER LB
C     OF THE TOTAL PRODUCT RECEIVED AT THE PROCESSING PLANT.
C     ($0.05 PER LB IS USED FOR THIS VALUE.)
C
C     PROJECTED MATERIAL HANDLING RATE (PMHR) AT THE PROCESSING
C     PLANT IS BASED ON THE NUMBER OF DECAPPERS.  MODEL ASSUMP-
C     TION --  3000 LBS PER HOUR PER  DECAPPER, 6000 LBS PER HR
C     PER SINGULATOR, 6000 LBS PER HR PER FINISHER.
C
C
C     MODEL ASSUMPTION -- NUMBER OF PROCESSING PLANT EMPLOYEES
C     (LESS ONE FOREMAN): 15 EMPLOYEES FOR OPTION #1
C                          9 EMPLOYEES FOR OPTION #2
C
      IF (OPTION.EQ.1) THEN
         PMHR=PROCTAB(5,2) * 3000
         NPPE = 15
      ELSE
         PMHR=PROCTAB(2,2) * 6000
         NPPE = 9
      ENDIF
C
C     PERM=PROCESSING EQUIPMENT R&M COST
C     TPRMC=TOTAL PROCESSING R&M COST
C     PRMCPA=PROCESSING R&M COST PER ACRE
C     GE=GENERAL EXPENSE
C     PH=PROCESSING HOURS
C     PPLC=PROCESSING PLANT LABOR COST
C     TOTPCPY=TOTAL PROCESSING COST PER YEAR
C     DPPP=DOLLARS PER LB PROCESSED
C     GC=GENERAL COST
C     PQ=PROJECTED QUANITIY PER YEAR
C     PRMP= PROCESSING R&M PERCENT
C     PVCPA=PROCESSING VARIABLE COST PER ACRE
C
      PRMP=3
      IF (OPTION.EQ.1) THEN
          LIMIT = 7
      ELSE
          LIMIT = 3
      ENDIF
      PERM=0
      DO 7 I=1,LIMIT
7     PERM=PERM + PROCTAB(I,1) * PROCTAB(I,2)
      TPRMC=PERM * (PRMP/100.)
      PRMCPA=TPRMC/ACRES
      PQ=YPA * ACRES * (HRVREC/100.)
      GC=0.05
      GE=GC * PQ
```

```
      PH=PQ/PMHR
      PPLC=NPPE * LABWAGE * PH
      TOTPCPY=TPRMC + GE + PPLC
      DPPP=TOTPCPY/PQ
      PVCPA=TOTPCPY/ACRES
C
C
      WRITE(6,'(/)')
      WRITE(6,*)'**************************************************'
      WRITE(6,10)
10    FORMAT( 12X,'PROCESSING PLANT VARIABLE COST')
      WRITE(6,20)
20    FORMAT('**************************************************')
      WRITE(6,'(//)')
      WRITE(6,30)
30    FORMAT(' REPAIR AND',6X,'GENERAL',6X,'PROCESS',5X,
     +'LABOR',5X,'COST PER',8X,'$ PER')
      WRITE(6,40)
40    FORMAT(' MAINTENANCE',5X,'EXPENSE',7X,'HOURS',6X,
     +'COST',8X,'YEAR',12X,'LB')
      WRITE(6,50) TPRMC,GE,PH,PPLC,TOTPCPY,DPPP
50    FORMAT('1',F11.2,2X,F11.2,4X,F7.1,3X,F9.2,2X,F12.2,6X,F6.2)
      WRITE(6,60)PVCPA
60    FORMAT('1',' PROCESSING VARIABLE COST PER ACRE',3X,F12.2)
      RETURN
      END
C     ************************************************************
C          **********  SUBROUTINE ECONOMIC ANALYSIS  **********
C     ************************************************************
      SUBROUTINE ECONAN(YPA,HRVRAT,HRVREC,FREEZE,FPRICE,
     +                  PUREE,PPRICE,OPTION)
C
C     ECONOMIC ANALYSIS -- PRODUCTION, MACHINE HARVEST
C     AND PROCESS.
C
      REAL TSIFC,TC,THVCST,RPTP,YPA,HRVREC,HRVRAT,FPC
      REAL TOTCPA,TYAA,TPFC,PVCPA,TRP,USABLE,RMC,PPQ
      REAL TOTR,FPR,FREEZE,FPRICE,PR,PUREE,PPRICE,DPPP
      REAL IRRCST(2,4),PROCST(7,4),SPECST(6,4)
      INTEGER ROW,OPTION
      COMMON / PECT / PROCST
      COMMON / SECT / SPECST
      COMMON / IECT / IRRCST
      COMMON / TPVCST / PVCPA,DPPP
      COMMON / FPCST / TYAA
C
      WRITE(6,'(////)')
      IF (OPTION.EQ.2) THEN
          ROW=3
      ELSE
          ROW=7
      ENDIF
      TPFC=0
      TSIFC=0
C    TSIFC=TOTAL SPECIALTY AND  IRRIGATION FIXED COST PER ACRE
      DO 3 I=1,ROW
3       TPFC=TPFC + PROCST(I,2)
C
```

```
      ROW=6
      DO 15 I=1,ROW
15       TSIFC=TSIFC + SPECST(I,2)
      ROW=2
      DO 13 I=1,ROW
13       TSIFC=TSIFC + IRRCST(I,2)
C
C     RPTP=RAW PRODUCT TO PROCESSING PLANT
      RPTP=YPA * (HRVREC/100.)
C
C     THE TOTAL HARVEST VARIABLE COSTS PER ACRE ARE ADDED
C     TOGETHER HERE FOR THE ECONOMIC ANALYSIS
C     TC = TRANSPORT COST FOR THE RAW PRODUCT FROM THE FIELD
C          TO THE PROCESSING PLANT.  A CUSTOM RATE IS USED FOR
C          THIS CALCULATION.  ($0.50 PER CWT -- DISTANCE 75
C          MILES PER LOAD)
C
      TC=(0.50/100.) * RPTP
C     THVCST=TOTAL HARVEST VARIABLE COST PER ACRE
      THVCST=SPECST(1,3)+SPECST(2,3)+SPECST(5,3)+SPECST(6,3)+TC
C     TOTCPA = TOTAL COST PER ACRE
      TOTCPA = TYAA + THVCST + TSIFC + TPFC + PVCPA
C
C
C     REVENUE ($/ACRE) FOR MACHINE HARVEST AND PROCESS
C     TOTAL SALES ($/ACRE) IS BASED ON THE DISTRIBUTION
C     OF THE FINAL PRODUCT.  FINAL PRODUCT IS VALUED ON
C     THE PERCENT DISTRIBUTION OF PRODUCT TO FREEZER
C     PACK  OR  PUREE.
C
C     USABLE = QUANTITY OF RAW PRODUCT DELIVERED TO THE
C              PROCESSING PLANT LESS THE TRASH.
C
C     TRP = TRASH PERCENT (TRP IS SET AT 10 TRASH)
      TRP=10
C
      USABLE = RPTP * (1- (TRP/100))
C
C     RMC = REVENUE MINUS COSTS
C     TOTR = TOTAL REVENUE
C
      IF (OPTION.EQ.1) THEN
         FPQ=USABLE*(FREEZE/100.)
         FPR=FPQ*FPRICE
         PPQ=USABLE - FPQ
         PR=PPQ*PPRICE
         TOTR = FPR + PR
      ELSE
         PR=USABLE*PPRICE
         FPR=0
         TOTR=FPR + PR
      ENDIF
      RMC=TOTR-TOTCPA
C
C
      WRITE(6,'(//)')
      WRITE(6,27)
      WRITE(6,20)
```

```
20     FORMAT('2',25X,'ECONOMIC ANALYSIS')
       WRITE(6,25)
25     FORMAT(10X,'-- PRODUCTION, MACHINE HARVEST AND PROCESS --')
       WRITE(6,27)
27     FORMAT('*************************************************************
      +******************')
       WRITE(6,30) TYAA
30     FORMAT('1','FIELD PRODUCTION COST PER ACRE ',24X,F12.2)
       WRITE(6,33) TSIFC
33     FORMAT('1','FIXED FIELD & IRR. EQUIP. COST PER ACRE',16X,
      +F12.2)
       WRITE(6,35) THVCST
35     FORMAT('1','HARVEST COST PER ACRE ',33X,F12.2)
       WRITE(6,40) TPFC
40     FORMAT('1','FIXED PROCESSING COST PER ACRE ',24X,F12.2)
       WRITE(6,45) YPA
45     FORMAT('1','TOTAL AVAILABLE RAW PRODUCT PER ACRE (#/ACRE)',
      +4X,F12.1)
       WRITE(6,50) HRVREC
50     FORMAT('1','HARVESTER RECOVERY EFFICIENCY',5X,F5.0)
       WRITE(6,55) RPTP
55     FORMAT('1','QUANTITY DELIVERED TO PROCESSING PLANT, LB/ACRE',
      +2X,F12.1)
       WRITE(6,60) DPPP,PVCPA
60     FORMAT('1','PROCESSING COST PER ACRE (',F5.3,'/LB)',20X,
      +F12.2)
       WRITE(6,63) TOTCPA
63     FORMAT('1','TOTAL COST PER ACRE',32X,F16.2)
       WRITE(6,64)
64     FORMAT('=============================================================
      +=================')
       WRITE(6,65)
65     FORMAT('1','REVENUE ($/ACRE) FOR MACHINE HARVEST AND PROCESS')
       WRITE(6,70)RPTP
70     FORMAT('1','TOTAL PRODUCT FOR PROCESSING',12X,F16.0,2X,'LB.')
       WRITE(6,75) USABLE
75     FORMAT('1','USABLE PRODUCT FOR PROCESSING',11X,F16.0,2X,'LB.')
       WRITE(6,80) FREEZE,PUREE
80     FORMAT('1','DISTRIBUTION OF PRODUCT',5X,'FREEZER PACK = ',
      +2X,F4.0,3X,'PUREE = ',2X,F4.0)
       WRITE(6,85) FPR
85     FORMAT('1','FREEZER PACK REVENUE',30X,'$',F16.2)
       WRITE(6,90) PR
90     FORMAT('1','PUREE REVENUE',37X,'$',F16.2)
       WRITE(6,95) TOTR
95     FORMAT('1',20X,'TOTAL REVENUE ($/ACRE)',8X,'$',F16.2)
       WRITE(6,97)
97     FORMAT('*************************************************************
      +*******************')
       WRITE(6,100) RMC
100     FORMAT('1',20X,'REVENUE MINUS COSTS ($/ACRE) ',5X,'$',F12.2)
C
C
       WRITE(6,'(///)')
       RETURN
       END
C      ***************************************************************
C            *********  SUBROUTINE FIELD PRODUCTION COST  *********
```

```
C     ****************************************************************
      SUBROUTINE FPCOST (ACRES,LABWAGE,OUTPUT)
C
      REAL TCP,TCD,TCC,TFC,TDC,TFUMG,TFEC,TFAC,CHEMCH,CHEMCHE
      REAL CHEMCI,CHEMCIE,CHEMCF,CHEMCFE,TTRANC,IRROC
      REAL BFCE,NFCE,HW,TECY1,TACY1,TFRC
      REAL TECY2,TACY2,RETCP,RETCD,RETCC,RETDC,RETFC
      REAL REFUMG,REAC,TREC,TRECA,TFPCY,IRVC
      REAL LABWAGE,ACRES,TYAA
      REAL MACH(6,1),MAT(5,2),CHEM(5,2)
      REAL SPECOST(6,4),IRRCOST(2,4)
      INTEGER OUTPUT
C
      COMMON / CRDT / MACH
      COMMON / FPDT / MAT,CHEM
      COMMON / SECT / SPECOST
      COMMON / IECT / IRRCOST
      COMMON / FPCST / TYAA
C
C --  CALCULATES THE FALL OPERATION COST
C
      TCP=MACH(1,1) * ACRES
      TCD=MACH(2,1) * ACRES
      TCC=MACH(3,1) * ACRES
      TFC=MAT(2,2) * MAT(2,1) * ACRES
      TDC=(MACH(4,1)+MAT(1,2)*MAT(1,1))*ACRES
      TFUMG=MAT(4,1) * ACRES
      TFEC=TCP+TCD+TCC+TDC+TFC+TFUMG
      TFAC=TFEC/ACRES
C --  CALCULATES THE FIRST YEAR TRANSPLANT COST
      CHEMCH=CHEM(1,1)*CHEM(1,2) + CHEM(2,2)*CHEM(2,1) + CHEM(3,1)*
     + CHEM(3,2)
      CHEMCHE=(CHEMCH + MACH(5,1))* ACRES * 2

      CHEMCI=CHEM(4,1)*CHEM(4,2)
      CHEMCIE=(CHEMCI + MACH(6,1)) * ACRES * 2
      CHEMCF=CHEM(5,1) * CHEM(5,2)
      CHEMCFE=CHEMCF * ACRES * 2
      TTRANC=(SPECOST(3,3) + (MAT(5,1) * MAT(5,2)/1000)) * ACRES
      IRVC=IRRCOST(1,3)+IRRCOST(2,3)
      IRROC=IRVC * ACRES
      BFCE=MAT(2,1)*MAT(2,2)*ACRES
      NFCE=(MAT(3,1)/2000 * MAT(3,2)) * ACRES * 2
      HW=LABWAGE * 18 * ACRES
      TECY1=TTRANC+TCC+IRROC+BFCE+NFCE+CHEMCHE+CHEMCIE+CHEMCFE+HW
      TACY1=TECY1/ACRES
C
      TFRC=SPECOST(4,3) * ACRES
      TECY2=TFRC+BFCE+NFCE+CHEMCHE+CHEMCIE+CHEMCFE+IRROC+HW
      TACY2=TECY2/ACRES
C  -- CALCULATIONS FOR THE RE-ESTABLISHMENT PERIOD --
      RETCP=(ACRES*.2)*MACH(1,1)
      RETCD=(ACRES*.2)*MACH(2,1)
      RETCC=(ACRES*.2)*MACH(3,1)
      RETDC=(ACRES*.2)*(MAT(1,2)*MAT(1,1) + MACH(4,1))
      RETFC=(ACRES*.2)*MAT(2,2)*MAT(2,1)
      REFUMG=(ACRES*.2)*MAT(4,1)
      REAC=ACRES*.2
```

```
C  -- TREA = TOTAL RE-ESTABLISHMENT COST
      TREC=RETCP+RETCD+RETCC+RETDC+RETFC+REFUMG
      TRECA=TREC/(ACRES*.2)
      TFPCY=TREC + TECY2
C  -- CALCULATIONS FOR THE SPRING TRANSPLANT RE-ESTABLISHMENT PERIOD
      ZTRANS=TTRANC * .20
      ZTCC=TCC * .20
      ZIRROC=IRROC * .20
      ZBFCE=BFCE * .20
      ZNFCE=NFCE * .20
      ZCHEMHE=CHEMCHE * .20
      ZCHEMIE=CHEMCIE * .20
      ZCHEMFE=CHEMCFE * .20
      ZHW=HW * .20
      TAFPC4=TFPCY/(ACRES + (ACRES * .20))
C
C     TCRCY = TOTAL CROP ROTATION COST PER YEAR
C     TACRCY = TOTAL ACRE CROP ROTATION COST PER YEAR
C
      TCRCY=TECY1 + TECY2 + TREC
      TACRCY=TCRCY/(ACRES + (ACRES * .20))
C
C   -- CALCULATE THE TEN YEAR AVERAGE --
C      TYAY = TEN YEAR AVERAGE PER YEAR
C      TYAA = TEN YEAR AVERAGE PER ACRE
C
      TYAY = (TFEC + TECY1 + (TECY2 * 2) + TFPCY + (TCRCY * 4))/10
      TYAA = (TFAC + TACY1 + (TACY2 * 2) + TAFPC4 + (TACRCY * 4))/10
C
      IF (OUTPUT.EQ.1) THEN
           GO TO 675
      ENDIF
      WRITE(6,'(////)')
      WRITE(6,100) ACRES
100   FORMAT(25X,'FARM SIZE',1X,F4.0,2X,'ACRES')
      WRITE(6,102)
102   FORMAT(24X,'-----------------------')
      WRITE(6,105)
105   FORMAT('1',' OPERATION',51X,'FALL')
      WRITE(6,110)
110   FORMAT('_____________',49X,'_______')
      WRITE(6,115)
115   FORMAT(' FALL',15X,'RATE PER',10X,'MATERIALS',12X,'TOTAL PER')
      WRITE(6,120)
120   FORMAT(' SOIL BUILDING',8X,'ACRE',12X,'PER ACRE',13X,
     +'ENTERPRISE')
      WRITE(6,125)
125   FORMAT('_______________',6X,'_________',10X,'__________',12X,
     +'___________')
      WRITE(6,130) MACH(1,1),TCP
130   FORMAT('1','PLOW',14X,F7.2,33X,F10.2)
      WRITE(6,135) MACH(2,1),TCD
135   FORMAT(' DISK',14X,F7.2,33X,F10.2)
      WRITE(6,140) MACH(3,1),TCC
140   FORMAT(' CULTI-MULCH',7X,F7.2,33X,F10.2)
      WRITE(6,145) MACH(4,1),MAT(1,2),MAT(1,1),TDC
145   FORMAT(' DRILLING',10X,F7.2,2X,'OATS',1X,F4.0,1X,
     +'LB/ACRE $',F6.2,1X,'/BU',2X,F10.2)
```

```
      WRITE(6,150)MAT(2,1),MAT(2,2),TFC
150   FORMAT(' FERTILIZER',2X,'CUSTOM APPLICATION $',F4.0,1X,
     +'/TON',2X,F5.2,1X,'TON/ACRE',1X,F10.2)
      WRITE(6,155) MAT(4,1),TFUMG
155   FORMAT(' FUMIGATION',2X,'CUSTOM APPLICATION $',F6.2,1X,
     +'PER ACRE',11X,F10.2)
      WRITE(6,160)
160   FORMAT(58X,'===========')
      WRITE(6,165) TFEC
165   FORMAT('1','TOTAL COST TO THE ENTERPRISE',28X,F12.2)
      WRITE(6,170) TFAC
170   FORMAT(' TOTAL-COST PER ACRE',37X,F12.2)
C
C --  WRITES AND FORMATS THE PRODUCTION COST FOR THE GROWING YEAR
C
      WRITE(6,'(////)')
      WRITE(6,200)
200   FORMAT(' SPRING - YEAR 1 -- GROWING YEAR',31X,'YEAR 1')
      WRITE(6,205)
205   FORMAT('________________________________________________________
     +______________')
      WRITE(6,210)
210   FORMAT(' OPERATION',7X,'$/ACRE',12X,'MATERIALS',16X,
     +'TOTAL PER').
      WRITE(6,215)
215   FORMAT(60X,'ENTERPRISE')
      WRITE(6,220)
220   FORMAT('___________',7X,'______',12X,'_________',16X,
     +'___________')
      WRITE(6,225) SPECOST(3,3),MAT(5,2),MAT(5,1),TTRANC
225   FORMAT('1','TRANSPLANT',5X,F6.2,2X,'PLANTS/ACRE',1X,F6.0,
     +1X,'$',F5.2,'/1000',6X,F10.2)
      WRITE(6,230) MACH(3,1),TCC
230   FORMAT(' PACKER',5X,'CUSTOM HIRE',2X,'$',F5.2,'/ACRE',
     +24X,F10.2)
      WRITE(6,235) IRVC,IRROC
235   FORMAT(' IRRIGATION OPERATING COST PER ACRE',3X,F6.2,
     +16X,F10.2)
      WRITE(6,240)
240   FORMAT(' FERTILIZER')
      WRITE(6,242)
242   FORMAT('___________')
      WRITE(6,245) MAT(2,1),MAT(2,2),BFCE
245   FORMAT(2X,'BROADCAST',1X,'1X',2X,'CUSTOM APPLICATION $',F4.0,
     +1X,'/TON',1X,F5.2,1X,'TON/ACRE',F10.2)
      WRITE(6,250) MAT(3,1),MAT(3,2),NFCE
250   FORMAT(2X,'NITROGEN',2X,'2X',14X,'$',F5.0,'/TON  RATE',
     +1X,F4.0,2X,'LB/AC',4X,F10.2)
      WRITE(6,255)
255   FORMAT(1X,'CHEMICALS')
      WRITE(6,257)
257   FORMAT('___________')
      WRITE(6,260) MACH(5,1),CHEMCH,CHEMCHE
260   FORMAT(2X,'HERBICIDE',3X,'2X',1X,'CUSTOM HIRE $',F5.2,
     +'/ACRE CHEM $',F5.2,'/AC',5X,F10.2)
      WRITE(6,265) MACH(6,1),CHEMCI,CHEMCIE
265   FORMAT(2X,'INSECTICIDE',1X,'2X',1X,'CUSTOM HIRE $',F5.2,
     +'/ACRE CHEM $',F5.2,'/AC',5X,F10.2)
```

```
      WRITE(6,270) CHEMCF,CHEMCFE
270   FORMAT(2X,'FUNGICIDE',3X,'2X',1X,'CHEMIGATION',18X,'$',
     +F5.2,'/AC',5X,F10.2)
      WRITE(6,275) LABWAGE,HW
275   FORMAT(' HAND WEEDING',2X,'$',1X,F4.2,1X,'/HR',15X,'RATE',
     +3X,'18 HR/AC',5X,F10.2)
      WRITE(6,280)
280   FORMAT(58X,'************')
      WRITE(6,285) TECY1
285   FORMAT('1','TOTAL ENTERPRISE COST YEAR 1',29X,F12.2)
      WRITE(6,290) TACY1
290   FORMAT(' TOTAL COST PER ACRE YEAR 1',31X,F12.2)
      WRITE(6,'(////)')
C
C --  WRITES AND FORMATS YEARS 2 AND 3
C
      WRITE(6,300)
300   FORMAT('  SPRING  - YEARS 2 AND 3       ---  HARVEST YEAR  ---',
     +5X,'YEARS 2 AND 3')
      WRITE(6,305)
305   FORMAT('_______________________________________________________________
     +_______________')
      WRITE(6,310)
310   FORMAT('1',' OPERATION',7X,'$/ACRE',11X,'MATERIALS',16X,
     +'TOTAL PER')
      WRITE(6,315)
315   FORMAT(60X,'ENTERPRISE')
      WRITE(6,320)
320   FORMAT('_____________',6X,'______',11X,'__________',16X,
     +'__________')
      WRITE(6,325) SPECOST(4,3),TFRC
325   FORMAT(' ROLL FIELD',6X,F6.2,36X,F10.2)
      WRITE(6,330)
330   FORMAT(' FERTILIZER')
      WRITE(6,332)
332   FORMAT('___________')
      WRITE(6,335) MAT(2,1),MAT(2,2),BFCE
335   FORMAT(2X,'BROADCAST',1X,'1X',2X,'CUSTOM HIRE $',F5.0,
     +'/TON RATE',1X,F4.2,1X,'TON/AC',4X,F10.2)
      WRITE(6,340) MAT(3,1),MAT(3,2),NFCE
340   FORMAT(2X,'NITROGEN',2X,'2X',14X,'$',F5.0,'/LB  RATE',
     +1X,F4.0,2X,'LB/AC',4X,F10.2)
      WRITE(6,345)
345   FORMAT(' CHEMICALS')
      WRITE(6,347)
347   FORMAT('___________')
      WRITE(6,350) MACH(5,1),CHEMCH,CHEMCHE
350   FORMAT(2X,'HERBICIDE',3X,'2X',1X,'CUSTOM HIRE $',F5.2,
     +'/ACRE CHEM $',F5.2,'/AC',4X,F10.2)
      WRITE(6,355) MACH(6,1),CHEMCI,CHEMCIE
355   FORMAT(2X,'INSECTICIDE',1X,'2X',1X,'CUSTOM HIRE $',F5.2,
     +'/ACRE CHEM $',F5.2,'/AC',4X,F10.2)
      WRITE(6,360) CHEMCF,CHEMCFE
360   FORMAT(2X,'FUNGICIDE',3X,'2X',1X,'CHEMIGATION',13X,
     +'CHEM $',F5.2,'/AC',4X,F10.2)
      WRITE(6,365) IRVC,IRROC
365   FORMAT(' IRRIGATION OPERATING COST PER ACRE',2X,F6.2,
     +16X,F10.2)
```

```
      WRITE(6,370) LABWAGE,HW
370   FORMAT(' HAND WEEDING',2X,'$',F4.2,1X,'/HR',15X,'RATE',
     +4X,'18 HR/AC',4X,F10.2)
      WRITE(6,375)
375   FORMAT(57X,'************')
      WRITE(6,380) TECY2
380   FORMAT('1','TOTAL ENTERPRISE COST PER YEAR',26X,F12.2)
      WRITE(6,385) TACY2
385   FORMAT(' TOTAL COST PER ACRE PER YEAR',28X,F12.2)
C
C --  WRITES AND FORMATS THE PRODUCTION COST FOR YEAR 4 AND THE
C     RE-ESTABLISHMENT PERIOD BEGINS
C
      WRITE(6,'(////)')
      WRITE(6,388)
388   FORMAT(',SPRING - YEAR 4       HARVEST YEAR  AND  BEGIN',
     +' RE-ESTABLISHMENT      YEAR 4')
      WRITE(6,305)
      WRITE(6,310)
      WRITE(6,315)
      WRITE(6,320)
      WRITE(6,325) SPECOST(4,3),TFRC
      WRITE(6,330)
      WRITE(6,332)
      WRITE(6,335) MAT(2,1),MAT(2,2),BFCE
      WRITE(6,340) MAT(3,1),MAT(3,2),NFCE
      WRITE(6,345)
      WRITE(6,347)
      WRITE(6,350) MACH(5,1),CHEMCH,CHEMCHE
      WRITE(6,355) MACH(6,1),CHEMCI,CHEMCIE
      WRITE(6,360) CHEMCF,CHEMCFE
      WRITE(6,365) IRVC,IRROC
      WRITE(6,370) LABWAGE,HW
      WRITE(6,375)
      WRITE(6,390) TECY2
390   FORMAT('1','TOTAL COST TO THIS POINT IN THE YEAR',20X,
     +F12.2)
      WRITE(6,392) TACY2
392   FORMAT(' TOTAL COST PER ACRE TO THIS POINT IN THE YEAR',
     +11X,F12.2)
C
C -------  RE-ESTABLISHMENT PERIODS BEGINS  ----------
C
      WRITE(6,400) REAC
400   FORMAT('1',17X,'RE-ESTABLISHMENT ACREAGE = ',F4.1,2X,'ACRES')
      WRITE(6,405)
405   FORMAT(17X,'____________________________________________')
      WRITE(6,410)
410   FORMAT('1',' OPERATION',51X,'FALL')
      WRITE(6,415)
415   FORMAT('___________',51X,'____')
      WRITE(6,420)
420   FORMAT(' FALL',14X,'RATE PER',9X,'MATERIALS',14X,
     +'TOTAL PER')
      WRITE(6,425)
425   FORMAT(' SOIL BUILDING',7X,'ACRE',11X,'PER ACRE',15X,
     +'ENTERPRISE')
      WRITE(6,430)
```

```
430   FORMAT('_______________',5X,'_________',9X,'__________',14X,
     +'___________')
      WRITE(6,435) MACH(1,1),RETCP
435   FORMAT(' PLOW',14X,F7.2,33X,F10.2)
      WRITE(6,440) MACH(2,1),RETCD
440   FORMAT(' DISK',14X,F7.2,33X,F10.2)
      WRITE(6,445) MACH(3,1),RETCC
445   FORMAT(' CULTI-MULCH',7X,F7.2,33X,F10.2)
      WRITE(6,450) MACH(4,1),MAT(1,2),MAT(1,1),RETDC
450   FORMAT(' DRILLING',10X,F7.2,2X,'OATS',1X,F4.0,1X,
     +'LB/ACRE $',F6.2,1X,'/BU',2X,F10.2)
      WRITE(6,455) MAT(2,1),MAT(2,2),RETFC
455   FORMAT(' FERTILIZER',2X,'CUSTOM APPLICATION $',F4.0,1X,
     +'/TON',2X,F5.2,1X,'TON/ACRE',1X,F10.2)
      WRITE(6,460) MAT(4,1),REFUMG
460   FORMAT(' FUMIGATION',2X,'CUSTOM APPLICATION $',F6.2,1X,
     +'PER/ACRE',11X,F10.2)
      WRITE(6,465)
465   FORMAT(58X,'===========')
      WRITE(6,470) TREC
470   FORMAT('1','TOTAL RE-ESTABLISHMENT COST',29X,F12.2)
      WRITE(6,475) TRECA
475   FORMAT(' TOTAL RE-ESTABLISHMENT COST PER ACRE',20X,F12.2)
      WRITE(6,480) TFPCY
480   FORMAT('1','TOTAL FIELD PRODUCTION COST FOR THE YEAR',16X,
     +F12.2)
      WRITE(6,485) TAFPC4
485   FORMAT(' TOTAL FIELD PRODUCTION COST PER ACRE FOR THE YEAR',
     +7X,F12.2)
C
C --  WRITES AND FORMATS THE PRODUCTION COST FOR THE COMPLETE CROP
C     PRODUCTION ROTATION FOR YEARS 5 THROUGH 10.
C
      WRITE(6,'(////)')
      WRITE(6,600)
600   FORMAT(' YEARS 5 TO 10        --   COMPLETE   ROTATION --',
     +10X,'YEARS 5 TO 10')
      WRITE(6,605)
605   FORMAT('1','SPRING TRANSPLANT   -- PRE-HARVEST OPERATIONS --',
     +2X,'FALL RE-ESTABLISHMENT')
      WRITE(6,'(//)'),
      WRITE(6,610)
610   FORMAT(20X,'SPRING TRANSPLANT OPERATIONS')
      WRITE(6,615)
615   FORMAT(20X,'________________________________')
      WRITE(6,'(//)')
      WRITE(6,205)
      WRITE(6,210)
      WRITE(6,215)
      WRITE(6,220)
      WRITE(6,225) SPECOST(3,3),MAT(5,2),MAT(5,1),ZTRANS
      WRITE(6,230) MACH(3,1),ZTCC
      WRITE(6,235) IRVC,ZIRROC
      WRITE(6,240)
      WRITE(6,242)
      WRITE(6,245) MAT(2,1),MAT(2,2),ZBFCE
      WRITE(6,250) MAT(3,1),MAT(3,2),ZNFCE
      WRITE(6,255)
```

```
      WRITE(6,257)
      WRITE(6,260) MACH(5,1),CHEMCH,ZCHEMHE
      WRITE(6,265) MACH(6,1),CHEMCI,ZCHEMIE
      WRITE(6,270) CHEMCF,ZCHEMFE
      WRITE(6,275) LABWAGE,ZHW
      WRITE(6,280)
      WRITE(6,620) TECY1
620   FORMAT('1','TOTAL ENTERPRISE COST PER YEAR',27X,F12.2)
      WRITE(6,625) TACY1
625   FORMAT(' TOTAL COST PER ACRE PER YEAR',29X,F12.2)
      WRITE(6,'(///)')
      WRITE(6,630)
630   FORMAT(20X,'PRE-HARVEST OPERATIONS')
      WRITE(6,'(//)')
      WRITE(6,305)
      WRITE(6,310)
      WRITE(6,315)
      WRITE(6,320)
      WRITE(6,325) SPECOST(4,3),TFRC
      WRITE(6,330)
      WRITE(6,332)
      WRITE(6,335) MAT(2,1),MAT(2,2),BFCE
      WRITE(6,340) MAT(3,1),MAT(3,2),NFCE
      WRITE(6,345)
      WRITE(6,347)
      WRITE(6,350) MACH(5,1),CHEMCH,CHEMCHE
      WRITE(6,355) MACH(6,1),CHEMCI,CHEMCIE
      WRITE(6,360) CHEMCF,CHEMCFE
      WRITE(6,365) IRVC,IRROC
      WRITE(6,370) LABWAGE,HW
      WRITE(6,375)
      WRITE(6,380) TECY2
      WRITE(6,385) TACY2
      WRITE(6,'(///)')
      WRITE(6,650)
650   FORMAT(20X,'FALL RE-ESTABLISHMENT OPERATION')
      WRITE(6,'(//)')
      WRITE(6,400) REAC
      WRITE(6,405)
      WRITE(6,410)
      WRITE(6,415)
      WRITE(6,420)
      WRITE(6,425)
      WRITE(6,430)
      WRITE(6,435) MACH(1,1),RETCP
      WRITE(6,440) MACH(2,1),RETCD
      WRITE(6,445) MACH(3,1),RETCC
      WRITE(6,450) MACH(4,1),MAT(1,2),MAT(1,1),RETDC
      WRITE(6,455) MAT(2,1),MAT(2,2),RETFC
      WRITE(6,460) MAT(4,1),REFUMG
      WRITE(6,465)
      WRITE(6,470) TREC
      WRITE(6,475) TRECA
      WRITE(6,'(///)')
      WRITE(6,480) TCRCY
      WRITE(6,485) TACRCY
675   WRITE(6,'(////)')
C
```

```
C --   WRITES AND FORMATS THE 10 YEAR FIELD PROD. COST SUMMARY TABLE
C
       WRITE(6,700)
700    FORMAT(25X,'SUMMARY  TABLE')
       WRITE(6,705)
705    FORMAT(21X,'FIELD PRODUCTION COST')
       WRITE(6,708)
708    FORMAT('***********************************************************
     +*************')
       WRITE(6,715)
715    FORMAT('1',27X,'$/YEAR',10X,'$/ACRE')
       WRITE(6,720)
720    FORMAT(28X,'------',10X,'------')
       WRITE(6,725) TFEC,TFAC
725    FORMAT(8X,'FALL',12X,F10.2,6X,F10.2)
       WRITE(6,730) TECY1,TACY1
730    FORMAT(8X,'YEAR 1',10X,F10.2,6X,F10.2)
       WRITE(6,735) TECY2,TACY2
735    FORMAT(8X,'YEAR 2',10X,F10.2,6X,F10.2)
       WRITE(6,740) TECY2,TACY2
740    FORMAT(8X,'YEAR 3',10X,F10.2,6X,F10.2)
       WRITE(6,745) TFPCY,TAFPC4
745    FORMAT(8X,'YEAR 4',10X,F10.2,6X,F10.2)
       DO 50 I=5,9
       WRITE(6,750) I,TCRCY,TACRCY
750    FORMAT(8X,'YEAR',1X,I1,10X,F10.2,6X,F10.2)
50     CONTINUE
       WRITE(6,760) TYAY,TYAA
760    FORMAT('1',2X,'TEN YEAR AVERAGE',3X,F12.2,4X,F12.2)
       WRITE(6,'(////)')
C
       RETURN
       END
C      ********************************************************
C           ********  SUBROUTINE FILLTAB  ***********
C      ********************************************************
       SUBROUTINE FILLTAB
C
       REAL RATETAB(6,1),MATCQ(5,2),CHEMCQ(5,2)
       REAL SPECTAB(6,6),PROCTAB(7,6),IRRTAB(2,6)
       CHARACTER*35 SKIP
C
       COMMON / CRDT / RATETAB
       COMMON / FPDT / MATCQ,CHEMCQ
       COMMON / SEDT / SPECTAB
       COMMON / PEDT / PROCTAB
       COMMON / IEDT / IRRTAB
C
       REWIND 7
C      READ INITIAL CUSTOM RATE VALUES INTO TABLE
       DO 5 I=1,6
5      READ(7,*) RATETAB(I,1)
C SKIP ONE SEPARATING RECORD
       READ(7,'(A1)') SKIP
C
C      READ INITIAL FIELD PRODUCTION MATERIALS
C      COSTS AND QUANTITIES INTO TABLE
       DO 10 I=1,5
```

```
10     READ(7,*) (MATCO(I,J),J=1,2)
C SKIP ONE SEPARATING RECORD
       READ(7,'(A1)') SKIP
C
C      READ INITIAL FIELD PRODUCTION CHEMICALS
C      COSTS AND QUANTITIES INTO TABLE
       DO 20 I=1,5
20     READ(7,*) (CHEMCQ(I,J),J=1,2)
C      SKIP ONE SEPARATING RECORD.
       READ (7,'(A1)') SKIP
C
C      READ INITIAL SPECIALTY EQUIPMENT VALUES
C      INTO TABLE
       DO 30 I=1,6
30     READ(7,*) (SPECTAB(I,J),J=1,6)
C      SKIP ONE SEPARATING RECORD.
       READ (7,'(A1)') SKIP
C
C      READ INITIAL PROCESSING EQUIPMENT VALUES
C      INTO TABLE
       DO 40 I=1,7
40     READ(7,*) (PROCTAB(I,J),J=1,6)
C      SKIP ONE SEPARATING RECORD.
       READ (7,'(A1)') SKIP
C
C      READ INITIAL IRRIGATION EQUIPMENT VALUES
C      INTO TABLE
       DO 50 I=1,2
50     READ(7,*) (IRRTAB(I,J),J=1,6)
C
C      RETURN TO BERRY
       RETURN
       END
*EDSOO  LINE=1541 SEC=1
```

The following data file (DATAFL1) lists the data file values used by the model. The values in this data file are based on the 1983-84 production cost values.

```
11.55
 7.85
 5.60
 5.90
 4.00
 4.90

  2.00   2.0
174.00   0.25
136.00  50.0
400.00   0.0
 61.00 10890.0

 1.1   5.0
11.0   1.0
16.3   1.5
16.9   0.5
 3.85  2.0

15000.0   1.0   15.0   0.0   .01   .0001
 1300.0   1.0   15.0   0.0   .01   .0002
 1150.0   1.0   15.0   0.0   .01   .00075
 1000.0   1.0   10.0   0.0   .01   .0004
70000.0   1.0   10.0   0.0   .01   .00025
   20.0  80.0   10.0   0.0   .01   .01

 1000.0   1.0   10.0   0.0   0.0   .00
 3500.0   1.0    8.0   0.0   0.1   .02
 1300.0   6.0   10.0   0.0   0.1   .02
 8000.0   1.0   10.0   0.0   0.1   .02
20000.0   2.0    8.0   0.0   0.1   .05
 3200.0   1.0   15.0   0.0   0.1   .01
 2500.0   1.0    8.0   0.0   0.1   .02

 0.0   0.0   15.0   0.0   0.01   0.07
 0.0   0.0   30.0   0.0   0.01   0.0

 9.9   9.9    9.9   9.9   9.9    9.9
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