ECONOMIC FEASIBILITY OF GREENHOUSE VEGETABLE PRODUCTION IN OKLAHOMA

By

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IN THE NAME OF ALLAH, MOST GRACIOUS, MOST MERCIFUL

ECONOMIC FEASIBILITY OF GREENHOUSE

VEGETABLE PRODUCTION IN OKLAHOMA

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CHAPTER I

INTRODUCTION

Problem Statement

In a young nation, the agricultural sector normally represents about 50 to 60 percent of Gross National Product of a country (Buse and Bromley). Many resources are usually involved in the agricultural production process. However, so many challenges face the agricultural sector. The severity of these challenges varies from one place to another. These challenges include water scarcity, soil fertility decline, and weather variability.

Actually, these challenges have negatively affected the agricultural production in many countries - if not all. Many farmers and researchers are induced by the emergence of these challenges to seek practical resolutions to them. The researchers and farmers develop many techniques to solve these challenges. For instance, the sprinkler system is used to mitigate frost damage. In addition, planting on raised beds covered in plastic is used to provide greater temperature and humidity in the root zone (Buckley et al). One of these developed techniques is the use of the greenhouse.

The greenhouse is a temporary structure whose main usefulness is to control the environment in which plants grow. The control process ensures the plant the availability of its required growth conditions that include light, temperature, humidity, nutrients, and carbon dioxide.

The controlled environment of the greenhouse enables growers to achieve three main benefits. The first benefit is to get the maximum attainable crop production with the use of scarce resources. The second benefit is to control the time of getting a crop produced, so that this crop provides a maximum return to the grower. The last main benefit is to allow cultivation in areas with extreme environments or in which cultivation has not been practiced. As a result, the greenhouse area worldwide has increased from 5000 acres in 1940 to 22500 acres in 1980, of which 10300 acres were used to grow vegetables (Maier et al).

However, the use of the greenhouse in crop production is not without problems. One of these is the relatively high initial investment and operating costs which have made the economic use of the greenhouses for vegetable production questionable. Consequently, many studies have been conducted to investigate the economic feasibility of greenhouses.

Pena conducted a study that analyzed the economic situation of the greenhouse tomato industry in south central United States. To achieve the proposed goal, data on initial investment cost, production cost, yield, and market price were collected. The collected data were statistically analyzed and converted to an economic profile of a typical greenhouse module. A greenhouse structure of 2880 square feet was selected. The analysis showed two reasons for the competitive disadvantage for firms in greenhouse vegetable industry: 1) the increased competition from alternative supply sources, and 2) the increased greenhouse production costs under a relatively elastic demand situation for fresh vegetable products. Results also indicated that the financial success of greenhouse tomato production is highly dependent on field and market prices, since operating costs are relatively inflexible.

Because of the continued interest in greenhouse tomato production in New Jersey, Dhillion and Brumfield made a survey of current greenhouse growers. The survey was designed to acquire and disseminate relevant economic information on the industry for the benefit of existing and prospective growers and policy makers. The economic information was used to analyze the economic feasibility of greenhouse tomato production in New Jersey. The greenhouse module chosen for the analysis consisted of three 2880 square feet greenhouses. The survey showed that greenhouse tomato production in New Jersey declined from its peak in the early 1970's even though the production technology has not altered much in the last few years. The survey further showed that growers have the potential to reduce their production unit cost by about one-half with full use of greenhouse alternative crops in the Fall season instead of concentrating on production of Spring crops alone. Results also showed that the average greenhouse operation in New

Jersey was profitable.

Bernd et al. compared the cost of producing greenhouse cucumbers in Las Cruces, New Mexico to ten selected competing sites in the United States. To reach the proposed objective, the authors identified and estimated the significant costs of constructing and operating a four acre greenhouse for each of the selected areas. The method used to estimate the production costs was the economic engineering method. They also estimated transportation cost. The study concluded that the costs of producing greenhouse cucumbers in Las Cruces, New Mexico were the lowest because the costs of major factors involved in producing greenhouse cucumbers were relatively low in Las Cruces, New Mexico.

Whittier and Fischer compared start-up capital and operating costs at 10 different United States locations to analyze the feasibility of establishing a new cut-flower operation. The study focused on the comparative advantages that southwest states have over other locations in the greenhouse industry in the United States. The study strongly indicated the profitability of new installations for cut-flower rose production in several areas in the southwest of the United States, particularly in New Mexico, Arizona, and Texas. The study also indicated the major advantages that southwest states have relative to the rest of the United States. These advantages are: a) the less expensive annual operating costs such as overall utility and labor costs, b) the natural resource endowments such as sunlight duration, low humidity, and low total heat requirements, and c) the large and skilled labor force that is both willing and able to work for competitive wage rates. Conclusively, the authors stated that because of enormous advantages that make the southwest states economically preferred locations, new growers to the industry should consider the region as a primary location for their greenhouse business planning.

Light is a major factor in producing organic material. Biggs has measured natural light and compared the physical properties of artificial and natural light. His work is important in the selection of artificial light sources for commercial enterprises. Janes and McAvoy studied the influence of adding light to greenhouse-grown produce, and concluded that the addition of supplementary light is economical under northeastern conditions. In their heat and lighting model, Gueymard et al. showed the impact of supplemental irradiance on vegetables. They found that heat loads were lower when supplemental irradiance was used. Also, the study indicated that the addition of light is economical and the reduction in heat loads is substantial because the light generates waste heat. Moreover, the study indicated that yield may increase as much as 40% in cucumbers because of the addition of light. In the 1970's, high energy cost forced many greenhouse growers out of business. As a result, conservation of energy and use of alternative sources have become more important (Maier et al).

Staley et al. investigated the economic feasibility of the energy conservation measure on investment in three glass greenhouse systems. The three glass greenhouse systems evaluated were 1) control greenhouse, 2) earth thermal storage (ETS) solar greenhouse, and 3) solar shed greenhouse. The authors accurately determined fuel consumption figures in the three glass greenhouses where thermal curtains were deployed randomly on successive pairs of Fall and Winter nights. That was done by constantly measuring the hot water flow rates through the heating pipes, and the supply and return water temperatures. These figures have been used in conjunction with long term weather data to determine the annual savings that could be anticipated in two regions. The first region was assumed to have a moderate coastal climate. The other region was assumed to have an extreme continental climate. A net present worth economic analysis was applied to the results to identify the relationship required between fuel, installation, and maintenance costs of thermal curtains. The results of the study indicated that thermal curtains capable of providing similar savings would be a profitable investment under most conditions, unless extremely high installation costs, crop losses, and cheap sources of fuel were available.

Brumfield et al. pursued a study that evaluated the economic feasibility of conventional and reject water heated greenhouses in Beaver County, Pennsylvania. Five reject water heating systems were considered; fluid floor, forced convection heat exchanges, surface heating, internal surface heating, and fluid canopy. For each system, glass and plastic greenhouse coverings were considered. A linear programming package was used to determine the crops' combination and quantity that maximize net returns to a conventional double layer polyethylene and reject water heated glass greenhouse. The economic analysis of this study revealed the conventional heating system showed a greater savings among the systems. The economic analysis further showed a positive cash flow for both conventional and rejected water heated greenhouses, and that a conventional greenhouse was more profitable than the reject water heated greenhouse.

Boggess and Amerling conducted a study that used a bioeconomic simulation model to analyze riskiness and return of irrigation investment in humid regions. Particular attention was given to the analysis of the influence of weather pattern variations on the profitability of an irrigation investment in humid regions. The bioeconomic simulation model was applied to an investment analysis in two irrigation systems. These systems were a center-pivot, and a travelling-gun irrigation system. Two other simulation models were used. The first one was a biological crop growth simulation model. This model was used to generate irrigated and dryland crops based on a time series of historical weather data. The generated results were integrated into a net present worth analysis. The other model was a Monte Carlo simulation model. It was used to generate the probability distribution of the net present worth (NPW's). In the study, the application of the bioeconomic simulation model showed the three results. One, there were a number of factors affecting profitability and risk of irrigation investments in humid regions. These factors include soil type, crop yield response to irrigation, future price, and financial variables. Two, the irrigation investment was quite risky although irrigation is regarded as a risk-reducing input. And three, there was tremendous variability in the investment's net present worth. This variability occurred because of uncertainty about the sequence of weather years in humid regions. That was true even with certainty of financial parameters, yield response, price, and cost over the system life. As a result, the study stated that the farmer traded a reduction in production risk for an increase in financial risk.

Basically, most of the studies focused on the economic justification of using greenhouses in different parts of the United States. Some studies focused on examining the characteristics of successful greenhouse operations and the important factors determining greenhouses' profitability. More efforts have been made to study the profitability of producing the Spring vegetable crops. Less effort has been exerted to study the economic feasibility of annual greenhouse use. However, no economic studies had been conducted for the use of greenhouses in Oklahoma.

In Oklahoma, 397 greenhouses have been in use (Table 1). They are currently producing bedding plants, potted

TABLE 1

OKLAHOMA GREENHOUSES BY SIZE

Number of Greenhouse	Average area square feet	% Total
14	>50000	3.5
22	20-50000	5.6
38	10-20000	9.6
323	<10000	81.3
397		100 %

Source: Certified Greenhouse and Nursery Directory, Oklahoma Department of Agriculture, 1990 plants, tropical plants, cucumbers, and tomatoes. The annual wholesale value of production from these greenhouses is at least $60 million. As a means of risk reduction, growers diversify their production to grow plants such as edible flowers, herbs, aloe vera for medical purposes, outdoor cut flowers, herbaceous perennials, and sometimes small nurseries to produce shrubs along with flowers. However, energy conservation is one of the major issues that concerns the growers in Oklahoma (Schnelle). Another major issue is the disease problems (personal contact with growers).

Objectives

This study is an attempt to fulfill the following objectives concerning greenhouse vegetable production in Oklahoma. These objectives are:

1- To determine the total investment costs for two common greenhouse growing systems.

2- To estimate costs and returns, and analyze cash flows for two common greenhouse growing systems.

3- To determine the economic feasibility of greenhouse vegetable production for two common growing systems under conditions of yield and price variability.

Scope and Limitations

The study is an attempt to determine the economic feasibility of greenhouse vegetable production in Oklahoma and focuses on tomato and cucumber productions. Further, the analysis focuses on the two common production systems being used in greenhouses: 1) the bed culture production system, and 2) the hydroponic production system. Many options are provided in the hydroponic production system. These options include bag culture, rockwool culture, a nutrient film technique (NFT) (Lamont and Marr), and piping system (Hochmuth). This study concentrates on the bag culture option of the hydroponic production system, and sheds light on the piping system.

Thesis Organization

The remainder of the study is divided into four chapters. Chapter II discusses the theoretical background and literature review. The chapter has two major focuses: 1) general overview of investment analysis in agriculture projects, and 2) sources of risk and risk management tools. An economic model and methodology of the study is presented in chapter III. Chapter IV discusses the data, analysis, and results of the economic model. Finally, Chapter V contains the conclusion and summary of the study.

CHAPTER II

THEORETICAL BACKGROUND AND LITERATURE REVIEW

The purpose of this chapter is to review the literature relevant to the study. It includes a general review of investment analysis in agriculture projects, sources of risk, and risk management tools.

General Overview of Investment in Agriculture Projects

Gwartney and Stroup defined investment as the flow of expenditures on both durable assets (fixed investment) and inventories (inventory investment) during a specified period. These expenditures enhance the potential of an economy to provide consumer benefits in future time periods. Gittinger defined investment as the use of the economy's resources to produce goods and services from which a return is expected to flow in future time. Mathematically, investment refers to a negative incremental cash flow accruing for a period of time. To choose among various investments, costs and benefits must be identified, priced, and valued. A decision maker must find a technique to evaluate investments that are of different durations and have variously shaped future cost and benefit streams. The usual technique for evaluating investments having these criteria is called the discounting approach. Discounting is a technique by which the future benefit and cost streams of an investment are reduced to their present value. This approach gives two primary discounted measures of investment value : 1) net present value (NPV), and 2) internal rate of return(IRR). Each measure provides a valid means for computing the profitability of the investment (Schreiner).

Net Present Value (NPV)

Net present value is the most straightforward discounted measure of an investment value. It is defined as the maximum amount a firm could pay for an investment in excess of its costs, assuming zero taxes (Harold and Smidt). Four steps are required to compute the net present value. These steps are: 1) the determination of an appropriate discount rate that should reflect the minimum acceptable rate of return, 2) the computation of the present value of the benefits of an investment, 3) the computation of the present value of the costs required by the investment, and 4) the summation of the difference between the present value of the investment benefits and costs which is referred to as the investment net present value (Aplin et al). The net present value model is expressed as:

$$NPV = \Sigma_{t=1}^{n} \frac{B_t - C_t}{(1 + i)^t}$$

Where

B_t = benefit in year t.

C_t = cost in year t.

n = number of years in the investment.

i = the discount rate.

If the net present value (NPV) is positive -- the present value of the benefit stream is more than the present value of the cost stream -- the investment is profitable, given the discount rate. The explicit criterion used in applying the net present value measure of investment value is to accept all independent investments with zero or greater net present value when discounted at the opportunity cost of capital (Gittinger).

Internal Rate of Return (IRR)

Gittinger defined internal rate of return (IRR) as the maximum interest that a project could pay for the resources used if the project is to recover its investment and operating costs and still break even. In other words, the investment earns back all capital and operating costs spent on it and pays the given discount rate for the money invested in the meantime. Barry et al. defined internal rate of return (IRR) as the rate of discount which equates the net present value of the projected series of cash flow payments to zero. Such a rate of discount may be found via one of two approaches: 1) setting the net present value model to zero and solving for the rate of discount that satisfies the model, or 2) determining an initial discount rate from certain discounting tables. The initial discount rate helps to find a discount rate that is low and another that is high. The low discount rate may give a positive net present value of the cash flow, whereas the high discount rate may give a negative net present value of the same cash flow. The true internal rate of return lies between the two discount rates and can be calculated by applying interpolation procedures to the two rates (Schreiner). The rule of interpolating is:

$$IRR = r_L + r_D(P_L/P_{LH})$$

where

r_L = lower discount rate

r_D = difference between the two discount rates

P_L = present value of incremental net benefit stream at the lower discount rate

P_{LH} = sum of present values of the incremental net benefit streams at the two discount rates (signs ignored)

The recommended criterion is to accept all independent investments having an internal rate of return equal to or greater than the opportunity cost of capital.

Discount Rate

The discount rate is one of the predominant factors affecting present value. It represents the required rate of return on the firm's equity, or the capital opportunity cost. The discount rate contains three components: 1) a risk free rate for time preference (i_t), 2) a risk premium that reflects the riskiness of the anticipated net cash flows (i_r), and 3) an expected inflation rate (i_f). Hence, the discount rate function is expressed as:

$$i = f(i_t,\ i_r,\ i_f)$$

When determining the present value of cost and benefit streams of investments, a decision maker should consider the effect of inflation on the cash flows and the discount rate. Inflation is an increase in the general level of prices for all goods and services in an economy. A positive rate of inflation reflects either the annual decline in purchasing power of a projected constant payment, or the annual increase of the nominal or money value of a projected constant payment by the designated inflation rate. Under inflationary conditions, both the payment series and the discount rate must be specified either in nominal values or in real values. Nominal values are the actual amount of currency comprising the cash flow. Real values reflect the purchasing power today of future cash flows. Real values are used in this study because of the difficulty in estimating different rates of inflation for individual cost items and prices of products.

The two basic approaches of risk measurement in investment analysis are: 1) adjusting the discount rate, and 2) the certainty equivalent approach. Both approaches consider the adjustment in cash flow necessary to make an investor indifferent between a risky and a safe investment.

In the case of a risky investment and a risk-averse investor, a simple method of accounting for risk in the investment is to add a risk premium to the risk-free rate. The risk premium reflects the riskiness on the expected cash flows of the investment. It represents the amount of return necessary to compensate the investor for accepting the risky investment. Adding the risk premium boosts the discount rate, and other things equal, would reduce the net present value of the investment, and hence its profitability. In practice, decision makers may formulate the risk premiums according to their risk attitudes and their assessment of the level of risk in an investment (Barry et al).

Another approach for accounting for risk in investment analysis is known as certainty equivalent. Certainty equivalent involves replacing the expected cash flows at each point in time by a certainty equivalent and discounting these certainty equivalents at the risk-free rate (Harold and Smidt). Using the certainty equivalent approach, the estimated cash flow is multiplied by a certainty equivalent coefficient (CEC) designated as α. The certainty equivalent coefficient varies inversely in value between zero and one with the degree of risk (Clark et al).

Risk in Agriculture

Source of Risk

Greenhouse vegetable production is a hard and risky business (Pena). Commercial greenhouse firms' investments may face both business and financial risks. Financial risk is associated with the firm's financial debts (Barry and Baker). It refers to increased variability of return to equity capital and reduction in liquid reserves of credit and financial assets (Barry et al). The ability of a firm to respond to unexpected and adverse events is diminished when both cash and credit reserves are reduced. The long run deterioration of economic conditions may cause firm's assets to diminish in valuation which may bring about an erosion of the firm's debt to equity positions. Restrained borrowing capacity and insolvency are often the results (Falk).

Business risk refers to the unexpected variability of firm's return. Greenhouse vegetable production is known for price variability. With price variability, a commercial greenhouse firm faces high variability of its net return. The variability of net return constitutes business risk.

Business risks have been classified into five major sources: production, marketing, technology, legal and social issues, and human resources (Sonka and Patrick). Production and marketing risks are the most effective business risk sources that affect the potential greenhouse yield and the average seasonal price.

Production risk is normally expressed in terms of yield variability, either decreased quantity or reduced quality or both. Yield variability, is caused mainly by some uncontrollable factors such as insect infestations and diseases. Several insects and viruses can seriously affect the greenhouse vegetable crops such as mosaic, vegetable leaf miner, and greenhouse thrips (Johnson and Hickman). Adverse temperature, excessive soil moisture, and poor nutrition are other causes of yield variability. Such yield variability increases the riskiness involved in greenhouse vegetable production.

Marketing risk is caused mainly by variability of saleable produce price, or input prices. In the short run, the variability of input prices may cause a great cash shortfall and income losses. In the long run, variability of input prices, interest rates, relative price movements, and expected inflation greatly affect the grower's decision about the investment. However, the grower's major concern is the variability of product prices (Sonka and Patrick).

Greenhouse vegetables are known for a relative elastic demand. As a result, if the price is too high or similar quality substitutes are available, greenhouse vegetables have the potential to "remain on the shelf". Marketing the crop is the area where most greenhouse operators fail. The lack of marketing experience and the degree of skill necessary to successfully produce above the break-even point are other problems. Because of these problems and other facts of the business, many new greenhouse vegetable growers do not survive financially (Pena).

Response to Risk

Diversification through enterprise selection or geographic dispersion, substitution of capital inputs for labor, and technical production practices are means adopted by growers in response to production risk. Marketing responses to risk include hedging on the future market, forward contracting, storage, sales spreading, and government program participation. Financial responses to risk include methods to maintain liquidity positions, such as asset leasing, share rental, and insurance (Sonka and Patrick). Fresh vegetable growers' ability to minimize or transfer risk is minimal because risk management tools are not available.

Production Responses to Risk

In the case of fresh vegetables, although selection is limited to the crop varieties that local climate and soil conditions permit and market analysis determines feasible, enterprise diversification is a viable production response to risk. However, there are some factors that constrain the possibility of risk reduction through diversification. Such factors are the total number of enterprises, correlations of returns among enterprises, and economics of scale gained through specialization. Economics of scale attainable from large scale production of fewer crops may be the greatest barrier that commercial firms face in using diversification as a risk management tool. Diversification is most effective in the absence of economics of scale in production.

Financial risk increases when the investment in assets such as specialized planting and harvesting equipment is required for vegetable production. Because of the highly management intensive nature of vegetable production, wide geographic dispersion is usually not an alternative available to small scale vegetable firms. In many cases, equipment cannot be substituted for labor for several reasons: 1) the mechanical means are not suitable for transplanting or harvesting, 2) the machinery available is not used, as in the case of fresh market tomatoes harvested by hand to prevent bruising, and 3) the investment in expensive specialized equipments by the small size of fruit and vegetable operations may not be justified. One production risk response that vegetable growers can use is to employ cultural practices that reduce yield variability (Falk).

Marketing Responses to Risk

Marketing responses to risk in vegetable production for the fresh market are also limited. Future markets do not exist for fresh vegetables. However, other means such as vertical coordination and integration may exist in fresh vegetable marketing in response to marketing risk involved in organizing production (Falk). Vertical integration is defined as the participation by one organization in more than one step in the production and marketing system through ownership (Black and Haskell). Vertical coordination involves a contractual relationship between growers and processors in which the delivery of a commodity at a future date and the pricing method are specified in writing. Forward contracts covered more than 50 percent of the produce grown for the processor, and between 10 and 50 percent of the produce grown for the fresh market (Sporleder and Holder). Since most fresh vegetables must be sold and consumed soon after harvest (except cabbage and potatoes), long term storage is generally not valid as a risk management tool (Falk).

Except for market orders, government programs do not exist for fresh products. Marketing orders provide another mechanism by which growers may initiate programs to regulate the marketing of their commodities to achieve orderly marketing through unified action. The order defines the commodity and market area to be regulated. Vegetable marketing orders give growers a degree of control over the quality and quantity of products that can move into fresh markets during the heaviest marketing season (Knutson et al).

CHAPTER III

MODEL AND METHODOLOGY

To achieve the proposed goals, the economic analysis is presented through four approaches: 1) development of total annual costs and returns budgets, 2) analysis of annual cash flows, 3) determination of multi-year net present values, and 4) analysis of risk associated with greenhouse vegetable production in Oklahoma.

Each one of these four approaches is applied to the following production practices: 1) annual greenhouse tomato production using the bed culture production system, 2) annual greenhouse cucumber production using the bed culture production system, 3) annual greenhouse tomato production using the bag culture production system, and 4) annual greenhouse cucumber production using the bag culture production system.

The Total Annual Costs and Returns Budgets

To examine the profitability of the greenhouse investment, the expect returns and costs should be correctly budgeted for producing the proposed crops. The expected costs are classified as fixed costs and variable (operating) costs. The fixed costs are incurred whether or not crops are produced. They include the depreciation, interest, and the property tax, and the property insurance on the initial investment. The variable (operating) costs, however, include all costs that vary with the quantity of the input being used in production. These costs include the costs of producing and marketing the crops as well as repairs and maintenance. The production costs consist of the operating input costs, the hired labor cost, the management charge, and the interest on operating capital. The seasonal production schedule is built on two-week periods for each crop using the two production systems.

The expected returns, on the other hand, are stated in two ways. The first, return above variable (operating) costs, is found by subtracting the variable (operating) costs from the total revenues. The second, return above variable (operating) and fixed costs, is found by subtracting the variable (operating) and fixed costs from the total revenues.

The Annual Cash Flow

The annual cash flow represents the expected values and time of all cash inflows and cash outflows. In this study, the annual cash flow is made on a monthly basis. For the monthly basis cash flow, the values and time of the cash inflow and the cash outflow entries are made directly in the appropriate month for each period. The annual cash flow formula is expressed as:

ACF = CIF - COF

ACF = the annual cash flow.

CIF = the annual cash inflows as a function of total crop sales (revenues).

COF = $f(I_O, L_H, M_R, R_M, I_C, P_T, P_I, G_M)$

COF = the annual cash outflow as a function of:

I_O = the operating input costs.

L_H = the hired labor cost.

M_R = the marketing cost.

G_M = the management charge.

R_M = the repair and maintenance costs.

I_C = the interest on the operating capital.

P_T = the property tax.

P_I = the property insurance.

The Multi-Year Net Present Value Model

The multi-year net present value model is used to estimate various issues that a grower may face in establishing and operating a commercial vegetable production venture. These include cash flow and financial issues. The multi-year net present value model also determines the overall profitability of the greenhouse module over a twenty-year planning horizon. The economic model is expressed as:

$$NPV_{s.v} = \sum_{n=0}^{m} \frac{S_n(P_n, Q_n) - C_n(INV_n, O_n, F_n)}{(1+i_{t.r})^n}$$

where

$INV_n = f(INS_n, INC_n, INE_n, INBW_n, INM_n, INT_n, R_n)$

F_n = $F(PI_n, PT_n)$

O_n = $f(B_n, R_n, M_n, G_n)$

$NPV_{s.v}$ = Net present value for production system S with crop v.

S_n = Total revenues in year n.

P_n = Average seasonal price.

Q_n = Quantity marketed.

C_n = Total costs in year n.

INV_n = Investment cost as a function of :

INS_n = Investment in structure that is replaced every 20 years.

INC_n = Investment in external cover that is replaced every 2 years.

INE_n = Investment in equipment that is replaced every 10 years.

$INBW_n$ = Investment in constructing beds and watering system that are replaced every 10 years.

INM_n = Investment in growing medium that is replaced every 2 years.

INT_n = Investment in minor tools and equipment that are replaced every 10 years.

R_n = purchase price of land and site preparation.

O_n = Variable (operating) costs as a function of :

B_n = production costs as a function of the operating input costs, hired labor cost, management charge, and interest on annual operating capital.

R_n = Repair and maintenance costs.

M_n = Marketing cost.

G_n = management charge.

F_n = fixed costs as a function of:

PT_n = Property tax.

PI_n = Property insurance.

m = number of years in the investment.

n = 0,1,2,.....,m

$i_{t,r}$ = adjusted real discount rate that account for riskiness of the investment.

If the multi-year net present value (NPV) is positive -- the present value of the total return is more than the present value of the total cost -- the greenhouse vegetable production investment is profitable, given the discount rate.

The Risk Analysis

To test systematically what happens to the earning capacity on a project if events differ from the estimates made about them in planning, and to deal with uncertainty about future events and value, sensitivity analysis is conducted by varying one element or more and determining the effect of that change on the outcome (Gittinger). In this study, sensitivity analysis is conducted by determining the effect of the potential vegetable yield reduction and discount rate variability on the greenhouse module's net present value. The potential yield may decline in quantity or quality when unexpected diseases attack the crops.

The Greenhouse Module

The greenhouse module chosen for the analysis is the ready made structure that provides 8640 square feet of production area. The 8640 square feet production area consists of three greenhouses, each one encompassing 2880 square feet and covered with a double layer of 6 mil plastic.

The essential facilities of each greenhouse are heating, cooling, and ventilation systems. Each greenhouse is equipped with two gas-fired heater systems and two evaporative cooling systems. The evaporative cooling system consists of a series of fans and cooling pads. In addition, each greenhouse is equipped with one ventilation system of thermostatically controlled fans and two exhausted fans. Two kind of exhausted fans are chosen: 1) 1/2 HP exhaust fans with a housing guard, and 2) 1/3 HP exhaust fans with a housing guard.

A total of eighteen beds are constructed length-wise in the greenhouse module. The beds are constructed on the greenhouse floor. An automated feeding system, an automated watering system, and a growing medium are installed in the greenhouse module. An automated feeding system is required in the hydroponic system to circulate a nutrient solution in times cycles. All nutrient solutions are applied through the irrigation system. An automated watering system is required in the bed culture and the bag culture production systems to supply water and fertilizer needs. The breakdown of the greenhouse module is shown in the appendix: The Initial Investment Costs.

CHAPTER IV

DATA, ANALYSIS AND RESULTS

The purpose of this chapter is to discuss the data and the analysis conducted, and to present the results of the economic analysis. The chapter can be divided into four sections 1) the total annual costs and returns budgets of greenhouse investment for each crop/production system, 2) the annual cash flow, 3) the multi-year net present value, and 4) the risk analysis.

The Total Annual Costs and Returns Budgets

The main components of the crop budget are the expected costs and returns. The expected costs can be classified as fixed and variable (operating) costs.

Fixed Costs

The fixed costs are incurred whether or not crops are produced. Fixed costs include the depreciation and interest on the initial investment components, property tax, and property insurance. Depreciation should reflect the actual decline in the asset's market value (Doye and Jobes). All greenhouse production systems require the use of similar environmental controls , shade structures, support wires, and general production practices. The major differences would be in the irrigation and nutrient delivery methods and controls (Sweat and Hochmuth). Watering system using the bag culture production system differs from that used in the bed culture production system by using nutrient injectors and storage tanks. Growing medium also varies among production systems in terms of media volume and formulas.

Land is not subject to an allowance for depreciation because it does not depreciate. In addition, the costs of preparing the land are not depreciable, since they are part of the land cost. However, the cost of using land is a real expense. It is not subject to income tax and should be accounted as a cost (Brumfield et al). The useful lives of the greenhouse's assets are not equal. Therefore, by estimating the useful life and salvage value of each asset, depreciation is calculated. No salvage value is assumed for any assets except for the growing medium. The salvage value of the growing medium is 50 percent. The initial investment interest is calculated by multiplying the average initial investment costs by 12 percent, the interest rate chosen to represent the expected real interest rate (Table 2).

Variable Costs

The variable (operating) costs include: 1) the production costs, 2) the marketing cost, and 3) the repair and maintenance costs.

The expected returns are stated in two ways. The first, return above variable costs that is calculated by subtracting the variable costs from the total crop sales.

TABLE 2

ANNUAL FIXED COSTS BY PRODUCTION SYSTEM

Item	Amount($)	
	Bed culture	Bag culture
Depreciation		
Greenhouse	614.84	614.84
External covering	858.38	858.38
Heating, cooling, and ventilating systems	1328.19	1328.19
Watering system	195.35	453.35
Beds	357.77	364.77
Growing medium	1316.52	445.97
Minor tools and equipment	295.53	295.53
Initial investment interest (6 percent)	3114.19	3064.26
Property tax (0.016)	830.45	817.13
Property insurance (0.008)	415.23	408.57
Total	9326.43	8650.98

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse Tomato Production In New Jersey, Sept 1990.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Greenhouse Structures and Systems. United Greenhouse System. Wisconsin.

The second, return above variable and fixed costs that is calculated by subtracting the variable and fixed costs from the total crop sales.

The Bed Culture Production System

Tomato Production

The Spring crop is the favorite of growers, since field grown tomatoes are scarce and the price is high. However, growers often raise both Spring and Fall crops to more fully utilized the fixed facility. To start the tomato production in the Spring (Fall) season, seeds are sown early in December (early in August). During early in February (the second week of September), plants are transplanted in the greenhouse beds after an intermediate transfer of seedlings to four inch pots.

Watering and fertilizing are carried out from the first week of February to the first week of July (the first week of September to the last week of December) in the Spring (Fall) season. A fertilizer program is usually planned so the phosphorous is applied at the time of soil preparation. Nitrogen and potassium fertilizers can be applied when needed by the growing tomato plants (Table 3). Water control is important. Soil should be checked at 4 to 6 inches to determine when watering is necessary. Overwatering is as bad as underwatering, so the soil moisture status is monitored using tensionmeters or similar equipments. A total of 62000 (42500) gallons of water is

TABLE 3

WATERING AND FERTILIZING REQUIREMENTS OF TOMATO PRODUCTION/MODULE: THE BED CULTURE PRODUCTION SYSTEM

Item	Unit	Spring Season Quantity	Spring Season $ Cost	Fall Season Quantity	Fall Season $ Cost
Water	gal	62000.00	62.00	42500.00	42.50
Fertilizer					
Mixed with the medium					
Magnesium Sulphate	lb	144.00	63.36	72.00	31.68
Dolomitic Limestone	lb	144.00	5.76	72.00	2.88
Calcium Nitrate (15.5 %ca)	lb	120.00	37.2	60.00	18.6
Super Phosphate (46 %p)	lb	240.00	45.6	120.00	22.8
Chelated Iron	lb	11.00	32.12	5.50	16.06
Fritted Trace elements	lb	45.00	96.75	22.50	48.38
For feeding plants					
Potassium Nitrate	lb	232.00	71.92	116.00	35.96
Calcium Nitrate	lb	146.00	45.26	73.00	22.63
15-15-15	lb	124.00	124	62.00	62
Chelated Iron	lb	3.00	8.76	1.50	4.38
Total fertilizer	lb	1209	530.73	604.5	265.37
Total	$		592.73		307.87

Sources:

Dhillion, P. S., and Brumfield, R. G. greenhouse tomato production in New Jersey, Sept 1990.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

required for the greenhouse module.

Pollination starts three weeks after transplanting seedlings in the greenhouse beds and ends 40-45 days before crop termination. That is, it occurs early in March to the third week of May (the second week of October to mid-November) in the Spring (Fall) season. Pollination is an important factor for blossoms of greenhouse tomatoes to set fruit. Pollination is generally done by vibrating each flower cluster that has open blooms. When blooms are numerous, pollination is carried out everyday, and every other day otherwise. The best time to pollinate is 10 a.m. to 2 p.m. on sunny days (Lamont and Marr). It is necessary to continue the pollinating procedure as long as there are open flowers (Brooks).

Stringing and pruning start two weeks after transplanting seedlings in the greenhouse beds and end 40-45 days prior to crop termination. That is, they occur from the last week of February to the third week of May (early in October to mid-November) in the Spring (Fall) season. Greenhouse tomatoes are pruned to a single stem by removing all lateral shoots. These lateral shoots should be removed when they are small to minimize injury to the main stem and leaf petiole. The pruning procedure is usually done during the stringing operation. Stringing is done by supporting the plants by twine. One end of the twine is attached to the base of the plant with a small, non-slip loop of sufficient size to permit stem expansion. The other is attached to a wire which is supported 6 to 8 feet above the plant row.

Disease control starts 3-4 weeks after transplanting seedlings in the greenhouse beds and ends late in the season. That is, it occurs early in March and continues to early in July (the second week of October to the last week of December) in the Spring (Fall) season. The main disease problems encountered in greenhouse tomato production are fusarium wilt, verticillium wilt, leaf mold, mosaic, and root knot nematode. Insects control, on the other hand, is carried out as needed. Several insects attack and damage greenhouse tomatoes. These insects are very difficult to control and may cause a loss of both quantity and quality of the crop. Common insect pests are mites, aphids, whiteflies, leaf miners, tomato fruitworm, and tomato pinworm (Lamont and Marr).

Harvesting the Spring (Fall) tomato crop lasts for 11 (6) weeks, from mid-April to early in July (mid-November to the last week of December). The length of growing season for the greenhouse tomatoes is 21 (15) weeks, from the first week of February to early in July (the second week of September to the last week of December). The season ends in the first week of July (late in December) by cleaning up the greenhouse and removing plants. The average tomato yield is 3142 (1571) pounds per week. On average, 720 (720) plants are grown in each greenhouse, using about 4 square feet of greenhouse space per plant. The average production per house is 11520 (3142) pounds and per greenhouse module is 34562 (9426) pounds. The total annual greenhouse tomato production is 43988 pounds. Table 4 shows the production costs and the operation schedule of the greenhouse tomato production in the Spring season, and Table 5 for the Fall season.

Cucumber Production

The Fall crop is the favorite of the growers, since field grown cucumbers are scarce and the price is high. For the Spring (Fall) cucumber production, seeds are sown early in December (early in August). During early February (the second week of September), plants are transplanted in the greenhouse beds after an intermediate transfer of the seedlings to four inch pots.

During the Spring (Fall) season, watering and fertilizing last for 21 (16) weeks, from the first week of February to the first week of July (the first week of September to the last week of December). Greenhouse cucumbers grow very quickly and should never lack water or nutrients. The total of 62000 (42500) gallons of water is required. Before planting, all the potassium and phosphorus needed are applied with a small amount of nitrogen. During crop growth, the most important element needed is nitrogen. It should be injected in the irrigation water during each irrigation using soluble fertilizer materials such as potassium nitrate (13 % N), calcium nitrate (16 % N), or ammonium nitrate (33 % N). The amount of fertilizer used per week in the Fall season is twice that of the Spring season since the average yield is twice that of the Spring

TABLE 4

THE PRODUCTION COSTS FOR PRODUCING A TOMATO SPRING CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

	Operation inputs	Unt	Amt	$/unt	$Total
	Natural Gas	mcf	864.00	2.25	1944.00
	Electricity	mo	8.00	160.00	1280.00
	Clips, 1", (3000/case)	case	9.00	61.00	549.00
	Tomato Twine	reel	3.00	67.25	201.75
	Seeds	seed	2160.00	0.095	205.20
	Pots	pot	2160.00	0.06	129.60
	Medium	cft	96.00	2.23	214.08
	Insecticides	bag	5.00	36.00	180.00
	Subtotal	$			4703.63

Month	Operation Schedule	$Total
December 1-15		
	Watering	1.55
	Plant seeds in flats	15.00
	Transplant seedlings to pots	37.50
15-31		
	Transplant seedlings to pots	37.50
	Watering	1.55
January 1-31		
	Watering	3.10
February 1-28		
	Transplanting in greenhouse beds	125.00
	Watering and Fertilizing	220.63
	Stringing & Pruning (4th week)	110.00
March 1-15		
	Pollination (1st week)	130.00
	Watering and Fertilizing	110.31
	Stringing & Pruning	220.00
	Disease control (1st week)	5.00

TABLE 4 (Continued)

Months	Operation Schedule	$Total
15-31		
	Pollination	130.00
	Watering and Fertilizing	110.31
	Stringing & Pruning	220.00
	Disease control	5.00
April 1-15		
	Disease control	5.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	119.27
	Pollination	130.00
15-30		
	Start Harvesting (3rd week)	270.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	119.27
	Pollination	130.00
	Disease control	5.00
May 1-31		
	Harvesting	540.00
	Stringing and Pruning (up to 3rd week)	330.00
	Watering and Fertilizing	238.55
	Pollination (up to 3rd week)	195.00
	Disease control	10.00
June 1-31		
	Harvesting	540.00
	Watering and Fertilizing	238.55
	Disease control	10.00
July 1-7		
	Disease control	2.50
	Watering and Fertilizing	59.64
	End Harvesting	135.00
	Clean up house & remove plants	120.00
	Management charge	3646.29

TABLE 4 (Continued)

Months	Operation Schedule	$Total
	Subtotal	8766.52
	Interest on operating capital	808.21
	Total Spring production costs	14278.36

Sources:

Dhillion, P. S.,and Brumfield, R.G. Greenhouse Tomato Production in New Jersey, Sept 1990

Cooperative Extension Service. Division of Agriculture, OSU. Department of Agriculture Economics, 1990.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Personal Contact With OSU Greenhouse Vegetable Extension Experts, 1991.

TABLE 5

THE PRODUCTION COSTS FOR PRODUCING A TOMATO FALL CROP,8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Operation inputs	Unt	Amt	$/unt	$Total
Natural gas	mcf	216.00	2.25	486.00
Electricity	mo	4.00	240.00	960.00
Clips, 1", (3000/case)	case	9.00	61.00	549.00
Tomato Twine	reel	3.00	67.25	201.75
Seeds	seed	2160.00	0.095	205.20
Pots	pot	2160.00	0.06	129.60
Medium	cft	96.00	2.23	214.08
Insecticides	bag	3.50	36.00	126.00
Subtotal	$			2871.63

Months	Operation Schedule	$Total
August 1-15		
	Watering	1.06
	Plant seeds in flats	15.00
	Transplant seedlings to pots	37.50
15-31		
	Transplant seedlings to pots	37.50
	Watering	1.06
September 1-30		
	Transplanting in greenhouse beds	125.00
	Watering and Fertilizing	180.51
October 1-15		
	Stringing & Pruning (1st week)	220.00
	Pollination (2nd week)	65.00
	Watering and Fertilizing	90.26
	Disease control (2nd week)	2.50
15-31		
	Pollination	130.00
	Stringing & Pruning	220.00

TABLE 5 (Continued)

Months	Operation Schedule	$Total
	Watering and Fertilizing	90.26
	Disease control	5.00
November 1-15		
	Pollination	130.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	106.18
	Disease control	5.00
15-30		
	Watering and Fertilizing	106.18
	Disease control	5.00
	Start harvesting (3rd week)	135.00
December 1-31		
	Harvesting	270.00
	Watering and Fertilizing	212.36
	Disease control	10.00
	Clean up house & remove plants	120.00
	Management charge	994.45
	Subtotal	3534.81
	Interest on operating capital	384.39
	Total Fall production costs	6790.82

Sources:

Dhillion, P. S.,and Brumfield, R.G. Greenhouse Tomato Production in New Jersey, Sept 1990

Cooperative Extension Service. Division of Agriculture, OSU. Department of Agriculture Economics, 1990.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Personal Contact With OSU Greenhouse Vegetable Extension Experts, 1991.

season (Table 6).

Stringing and pruning continue from the last week of February to the third week of May (the first week of October to mid-November) in the Spring (Fall) season. Cucumber plants are supported by strings suspended from a horizontal wire. The overhead support wire is located 7 to 8 feet above the plant rows. The string is anchored to the base of each plant with a loose non-slip knot. An umbrella system is the most common way of pruning cucumber plants. In this system, all lateral branches are removed as they develop until the cucumber plant reaches the overhead support wire. At this stage, the terminal bud is removed after the second leaf above the wire and the last two lateral branches are allowed to grow. These laterals are trained over the wire and allowed to grow downward to about 3 feet above ground. Fruits should not be allowed to develop on the lower 30 inches of the main stem to encourage the cucumber plants rapid vegetative development. Main stem fruits above that point are allowed to develop at the base of each leaf.

Control of disease is carried out from early March to early July (the second week of October to the last week of December) in the Spring (Fall) season. Several disease and insect pests attack and damage greenhouse cucumbers. The serious diseases include cucumber and watermelon mosaic, gray mold, powderly mildew, and root knot nematodes. In addition, other troublesome insect pests include the white fly, serpentine leaf miner and two-spotted mite (Lamont and

TABLE 6

WATERING AND FERTILIZING REQUIREMENTS OF CUCUMBER PRODUCTION/MODULE: THE BED CULTURE PRODUCTION SYSTEM

		Spring Season		Fall Season	
Items	Unit	Quantity	$Cost	Quantity	$Cost
Water	gal	62000.00	62.00	42500.00	42.50
Fertilizer					
<u>Seedling to first fruit set</u>					
Magnesium Sulphate	lb	31.00	13.64	62.00	27.28
Monopotassium (0-22.5-28)	lb	16.50	4.95	33.00	9.90
Potassium Nitrate (13-0-44)	lb	12.50	3.88	25.00	7.75
Calcium Nitrate	lb	42.00	13.02	84.00	26.04
Chelated Iron	lb	1.50	4.38	3.00	8.76
Micro-Nutrient	lb	0.15	0.17	0.30	0.33
<u>Fruit set to crop termination</u>					
Magnesium Sulphate	lb	53.00	23.32	106.00	46.64
Monopotassium (0-22.5-28)	lb	28.50	8.55	57.00	17.10
Potassium Nitrate (13-0-44)	lb	12.25	6.59	42.50	13.18
Calcium Nitrate	lb	144.50	44.80	289.00	89.59
Chelated Iron	lb	2.50	7.30	5.00	14.60
Micro-Nutrient	lb	0.25	0.28	0.50	0.56
Total Fertilizer	lb	353.65	130.86	707.30	261.72
Total	$		192.86		304.22

Sources:

Hochmuth, G (Ed).Florida: Greenhouse Vegetable Production Handbook (3) 1991.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Dhillion, P. S.,and Brumfield, R.G. Greenhouse Tomato Production in New Jersey, Sept 1990

Marr).

Harvesting the Spring (Fall) cucumber crop lasts for 14 (8) weeks, starting from the last week of March to early in July (the first week of November to the last week of December). The length of the Spring (Fall) growing season in greenhouse cucumbers is 21 (15) weeks, from early in February to the first week of July (early in September to the last week of December). The season ends in the first week of July (late in December) by cleaning up the greenhouse and removing plants. In the Spring (Fall) season, average yield for cucumbers is about 1620 (3240) pounds per week. On average, 576 (576) plants are grown in each greenhouse. The average production per house is 7560 (8640) pounds and per operation is 22680 (25920) pounds. The total annual greenhouse cucumber production is 48600 pounds. Table 7 (8) shows the total production costs and the operating schedule of the greenhouse cucumber production in the Spring (Fall) season.

Labor Cost

Greenhouse production of any crop is a labor-intensive enterprise. Greenhouse vegetable production requires high skilled labors. The skilled labors are needed to perform certain operations that have not been mechanized. These operations include transplanting, pruning, stringing, pollinating, and harvesting. The season of either tomatoes or cucumbers begins with the sowing of seed and nurturing of seedlings before they are ready for transplanting. The new

TABLE 7

THE PRODUCTION COSTS FOR PRODUCING A CUCUMBER SPRING CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Operation inputs	Unt	Amt	$/unt	$Total
Natural Gas	mcf	864.00	2.25	1944.00
Electricity	mo	8.00	160.50	1280.00
Clips, 1", (3000/case)	case	9.00	61.00	549.00
Cucumber Twine	reel	3.00	67.25	201.75
Seeds	seed	1440.00	0.45	648.00
Pots	pot	1440.00	0.06	86.40
Medium	cft	96.00	2.23	214.08
Insecticides	bag	5.00	36.00	180.00
Subtotal	$			5103.23

Months	Operation Schedule	$Total
December 1-15		
	Watering	1.55
	Plant seeds in flats (Dec 1st)	15.00
	Transplant seedlings to pots	37.50
15-31		
	Transplant seedlings to pots	37.50
	Watering	1.55
January 1-31		
	Watering	3.10
February 1-28		
	Transplanting in greenhouse beds	125.00
	Watering and Fertilizing	150.65
	Stringing & Pruning (4th week)	110.00
March 1-15		
	Watering and Fertilizing	75.33
	Stringing & Pruning	220.00
	Disease control (1st week)	5.00
15-31		
	Watering and Fertilizing	75.33
	Stringing & Pruning	220.00

TABLE 7 (Continued)

Months	Operation Schedule	$Total
	Disease control	5.00
	Start harvesting (4th week)	67.50
April 1-15		
	Harvesting	135.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	79.29
	Disease control	5.00
15-30		
	Harvesting	135.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	79.29
	Disease control	5.00
May 1-15		
	Harvesting	135.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	79.29
	Disease control	5.00
15-31		
	Harvesting	135.00
	Stringing & Pruning (up to 3rd week)	110.00
	Watering and Fertilizing	79.29
	Disease control	5.00
June 1-30		
	Harvesting	270.00
	Watering and Fertilizing	158.57
	Disease control	10.00
July 1-7		
	Harvesting	67.50
	Watering and Fertilizing	39.64
	Disease control	2.50
	Clean up house and remove plants	120.00
	Management charge	2177.28

TABLE 7 (Continued)

Months	Operation Schedule	$Total
	Subtotal	5642.64
	Interest on operating capital	644.75
	Total production Costs	11390.62

Sources:

Dhillion, P. S., and Brumfield, R.G. Greenhouse Tomato Production in New Jersey, Sept 1990

Cooperative Extension Service. Division of Agriculture, OSU. Department of Agriculture Economics, 1990.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Personal Contact With OSU Greenhouse Vegetable Extension Experts, 1991.

TABLE 8

THE PRODUCTION COSTS FOR PRODUCING A CUCUMBER FALL CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Operation Inputs	Unt	Amt	$/unt	$Total
Natural gas	mcf	216.00	2.25	486.00
Electricity	mo	4.00	240.00	960.00
Clips, 1", (3000/case)	case	9.00	61.00	549.00
Cucumber Twine	reel	3.00	67.25	201.75
Seeds	seed	1440.00	0.45	648.00
Pots	pot	1440.00	0.06	86.40
Medium	cft	96.00	2.23	214.08
Insecticides	bag	3.50	36.00	126.00
Subtotal	$			3271.23

Months	Operation Schedule	$Total
August 1-15		
	Watering	1.06
	Plant seeds in flats	15.00
	Transplant seedlings to pots	37.50
15-31		
	Transplant seedlings to pots	37.50
	Watering	1.06
September 1-30		
	Transplanting in greenhouse beds (2nd week)	125.00
	Watering and Fertilizing	179.78
October 1-15		
	Stringing & Pruning (1st week)	220.00
	Watering and Fertilizing	89.89
	Disease control (2nd week)	2.50
15-31		
	Stringing & Pruning	220.00
	Watering and Fertilizing	89.89
	Disease control	5.00

TABLE 8 (Continued)

Months	Operation Schedule	$Total
November 1-15		
	Start harvesting	270.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	105.63
	Disease control	5.00
15-30		
	Watering and Fertilizing	105.63
	Disease control	5.00
	Harvesting	270.00
December 1-15		
	Harvesting	270.00
	Watering and Fertilizing	105.63
	Disease control	5.00
15-31		
	Harvesting	270.00
	Watering and Fertilizing	105.63
	Disease control	5.00
	Clean up house and remove plants	120.00
	Management charge	2488.32
	Subtotal	5375.04
	Interest on operating capital	518.78
	Total Fall production Costs	9165.05

Sources:

Dhillion, P. S., and Brumfield, R.G. Greenhouse Tomato Production in New Jersey, Sept 1990

Cooperative Extension Service. Division of Agriculture, OSU. Department of Agriculture Economics, 1990.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Personal Contact With OSU Greenhouse Vegetable Extension Experts, 1991.

medium is mixed and placed in beds. Then, plants are transplanted in greenhouse beds. Watering, fertilizing, stringing, pruning of plants, and pollination of blossoms are performed routinely. Harvesting activities such as picking, grading, and packing are carried out two or three times a week. The season ends with the clean up of the greenhouse and removal of the plants. The average labor requirement for producing tomatoes varies from 5-60 (5-38) hours per week in the Spring (Fall) season per greenhouse module, whereas the average labor requirement for producing cucumbers varies from 5-42 (5-45) hours per week in the Spring (Fall) season per greenhouse module. The average wage rate for both crops productions is assumed to be $5 per hour. The main difference between the average labor requirement of producing the two crops is that the pollinating activity is not required for cucumber production (McCraw). Tables 9, 10, 11, and 12 show the breakdown and the total costs of required labors to produce tomatoes and cucumbers in the Spring and the Fall seasons.

<u>Annual Total Return Per Module</u>

In Table 13 the total annual variable costs required to produce tomatoes using the bed culture production system, $23850.20, are subtracted from the total annual tomato sales $46407.34, to give the return above the variable costs of $22557.14, or about $2.61 per square feet of the greenhouse module. However, the return above all costs (fixed, variable) but risk is $13230.70, or about $1.53 per square

TABLE 9

LABOR REQUIREMENTS FOR PRODUCING A SPRING TOMATO CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Activity	Unt	Amt	week	$Total
Growing Seedlings	hr	3.00	1.00	15.00
Growing Transplants	hr	15.00	Once/Seas	75.00
Transplanting	hr	25.00	Once/Seas	125.00
Stringing & Pruning[1]	hr	264.00	12.00	1320.00
Pollinating[1]	hr	143.00	11.00	715.00
Watering and Fertilizing	hr	126.00	21.00	630.00
Harvesting and Packing[1]	hr	297.00	11.00	1485.00
Disease control0	hr	8.50	17.00	42.50
Removal of Plants and House Cleanup	hr	24.00	Season	120.00
Total	hr	905.50		
Total	$			4527.50

Source:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

1. Personal contact with Oklahoma greenhouse operators, Nov 1991

TABLE 10

LABOR REQUIREMENTS FOR PRODUCING A FALL TOMATO CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Activity	Unt	Amt	week	$Total
Growing Seedlings	hr	3.00	1.00	15.00
Growing Transplants	hr	15.00	Once/Seas	75.00
Transplanting	hr	25.00	Once/Seas	125.00
Stringing & Pruning[1]	hr	132.00	6.00	660.00
Pollinating[1]	hr	65.00	5.00	325.00
Watering and Fertilizing	hr	96.00	16.00	480.00
Harvesting and Packing[1]	hr	81.00	6.00	405.00
Disease control	hr	5.50	11.00	27.50
Removal of Plants and House Cleanup	hr	24.00	Season	120.00
Total	hr	446.50		
Total	$			2232.50

Source:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

1. Personal contact with Oklahoma greenhouse operators, Nov 1991

TABLE 11

LABOR REQUIREMENTS FOR PRODUCING A SPRING CUCUMBER CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Activity	Unt	Amt	week	$Total
Growing Seedlings	hr	3.00	1.00	15.00
Growing Transplants	hr	15.00	Once/Seas	75.00
Transplanting	hr	25.00	Once/Seas	125.00
Stringing & Pruning[1]	hr	264.00	12.00	1320.00
Watering and Fertilizing	hr	126.00	21.00	630.00
Harvesting and Packing[1]	hr	189.00	14.00	945.00
Disease control	hr	8.50	17.00	42.50
Removal of Plants and House Cleanup	hr	24.00	Season	120.00
Total	hr	654.50		
Total	$			3272.50

Source:

Dhillon, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

1. Personal contact with Oklahoma greenhouse operators, Nov 1991

TABLE 12

LABOR REQUIREMENTS FOR PRODUCING A FALL CUCUMBER CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Activity	Unt	Amt	week	$Total
Growing Seedlings	hr	3.00	1.00	15.00
Growing Transplants	hr	15.00	Once/Seas	75.00
Transplanting	hr	25.00	Once/Seas	125.00
Stringing & Pruning[1]	hr	132.00	6.00	660.00
Watering and Fertilizing	hr	96.00	16.00	480.00
Harvesting and Packing[1]	hr	216.00	8.00	1080.00
Disease control	hr	5.50	11.00	27.50
Removal of Plants and House Cleanup	hr	24.00	Season	120.00
Total	hr	516.50		
Total	$			2582.50

Source:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

1. Personal contact with Oklahoma greenhouse operators, Nov 1991

TABLE 13

ANNUAL TOTAL RETURN AND BREAK EVEN COST/MODULE, TOMATO PRODUCTION: THE BED CULTURE PRODUCTION SYSTEM

	Unt	Amt
Total Revenue	$ per module	46407.34
Revenue	$ per sq. ft.	5.37
Total Variable Costs	$ per module	23850.20
Variable Costs	$ per sq. ft.	2.76
Return above Variable Costs	$ per module	22557.14
Return above Variable Costs	$ per sq. ft.	2.61
Total Costs	$ per module	33176.64
Total Costs	$ per sq. ft.	3.84
Net Profit	$ per module	13230.70
Net Profit	$ per sq. ft.	1.53
Total Production	pounds	43988.00
Break even cost	$ per pound	0.75

feet of the greenhouse module.

Table 14 shows that the total annual variable costs required to produce cucumbers, $27698.59, are subtracted from the total annual cucumber sales, $46656, to give the return above the variable costs of $18957.41, or about $2.19 per square feet. However, the return above all costs (fixed, variable) but risk is $9630.97, or about $1.11 per square feet of the greenhouse module.

From the above results, greenhouse tomato production using the bed culture production system is more attractive than greenhouse cucumber production to the investors of the greenhouse industry.

Break Even Cost

One of the true measure of risk is to compare the break even cost to produce a commodity with the price expected from the sale of the product. Tables 13 and 14 show a summary of the break even cost. If the tomato (cucumber) total fixed and variable costs, $33176.64 ($37025.03), are divided by the total tomato (cucumber) production 43988 (48600) pounds, the break even tomato (cucumber) production cost is $.75 ($.76) per pound. In other words, the production costs for the greenhouse tomatoes (cucumbers) using the bed culture production system average over $.75 ($.76) per pound assuming an average Spring (Fall) tomato yield of 3142 (1571) pounds per week, and an average Spring (Fall) cucumber yield of 1620 (3240) pounds per week. Then, the greenhouse growers must sell the tomato (cucumber) crop

TABLE 14

ANNUAL TOTAL RETURN AND BREAK EVEN COST/MODULE, CUCUMBER PRODUCTION: THE BED CULTURE PRODUCTION SYSTEM

	Unt	Amt
Total Revenue	$ per module	46656.00
Revenue	$ per sq. ft.	5.40
Total Variable Costs	$ per module	27698.59
Variable Costs	$ per sq. ft.	3.21
Return above Variable Costs	$ per module	18957.41
Return above Variable Costs	$ per sq. ft.	2.19
Total Costs	$ per module	37025.03
Total Costs	$ per sq. ft.	4.29
Net Profit	$ per module	9630.97
Net Profit	$ per sq. ft.	1.11
Total Production	pounds	48600.00
Break even cost	$ per pound	0.76

for at least \$.75 (\$.76) per pound to be in business, and choose not to produce otherwise.

The Bag Culture Production System

The second common greenhouse production system in Oklahoma is the bag culture production system. This system consists of filling 4 millimeter black or white polyethylene bags of 5 gallon volume with 1/2 to 3/4 cubic feet of growing medium. The bags have drain holes. One plant is placed in each bag, with the bags spaced 16 to 18 inches apart in a row. A complete nutrient solution is fed through a plastic spray stake in each bag. The nutrient solution is usually provided from liquid concentrate diluted through a fertilizer proportioner (Johnson and Hickman).

Tomato Production

For the Spring (Fall) season, tomato plants are grown in commercially prepared or grower-filled bags which contain between 1/2 and 3/4 cubic feet (CF) of medium per plant. Time from seedlings to pricking out into 4 inch pots is 10 days. Tomato seeds are sown early in December (early in August). Prior to pricking out, seedlings in pearlite medium are placed in 4 inch bottomless pots. Transplants are placed in bags early in February (the second week of September). Bags containing the medium should be placed in double rows at the proper spacing, with the irrigation system placed next to the bags between the double rows.

Watering and fertilizing last for 21 (16) weeks, from the first week of February to the first week of July (the first week of September to the last week of December) in the Spring (Fall) season. A total of 62000 (42500) gallons of water is used. The irrigation system should be turned on immediately after transplanting and run at intervals until a gallon of fertilizer-enriched water has been applied to each plant. Side slits should be made in the bags after the medium in the bag becomes uniformly wet. Watering may be on a once-a-day schedule when the tomato plants are young. The frequency of irrigation increases as the tomato plants begin to grow (Bauerle).

The tomato plants can be grown with complete nutrient solution alone, with a complete N-P-K slow release fertilizer, or with a combination of the two materials. Rates for the material should be reduced to 30 to 40 percent when used in combination. Nutrient solution is applied at every irrigation through spray sticks or spaghetti tubes. Frequency of application will depend upon tomato plant size and greenhouse temperature, but will vary from once or twice daily immediately after transplanting to several time per day on warm days during harvest (Table 15).

Stringing and pruning last for 12 (6) weeks, from the last week of February to the third week of May (the first week of October to mid-November). Pollination lasts for 11 (5) weeks, from the first week of March to the third week of May (the second week of October to mid-November) in the Spring (Fall) season. Disease control is carried out 3-4 week after transplanting seedlings in the greenhouse beds

TABLE 15

WATERING AND FERTILIZING REQUIREMENTS OF TOMATO PRODUCTION/MODULE: THE BAG CULTURE PRODUCTION SYSTEM

Items	Unit	Spring Season Quantity	Spring Season $Cost	Fall Season Quantity	Fall Season $Cost
Water	gal	62000.00	62.00	42500.00	42.50
Fertilizer					
Seedlings to first fruit set					
Magnesium Sulphate	lb	103.00	45.32	51.50	22.66
Monopotassium (0-22.5-28)	lb	56.00	16.80	28.00	8.40
Potassium Nitrate(13-0-44)	lb	41.00	12.71	20.50	6.35
Potassium Sulphate (50%K)	lb	21.00	6.30	10.50	3.15
Calcium Nitrate (15.5 %ca)	lb	103.00	31.93	51.50	15.97
Chelated Iron	lb	5.00	14.60	2.50	7.30
Micro Nutrient	lb	0.50	0.56	0.25	0.28
Fruit set to crop termination					
Magnesium Sulphate	lb	129.00	56.76	64.50	28.38
Monopotassium (0-22.5-28)	lb	70.00	21.00	35.00	10.50
Potassium Nitrate(13-0-44)	lb	52.00	16.12	26.00	8.06
Potassium Sulphate(50%K)	lb	26.00	7.80	13.00	3.90
Calcium Nitrate (15.5 %ca)	lb	176.00	54.56	88.00	27.28
Chelated Iron	lb	6.50	18.98	3.25	9.49
Micro Nutrient	lb	0.60	0.67	0.30	0.33
Total fertilizer	lb	789.60	304.10	394.80	152.05
Total	$		366.10		194.55

Sources:

Hochmuth, G (Ed).Florida: Greenhouse Vegetable Production Handbook (3) 1991.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Dhillon, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990 all through to the end of the season.

Harvesting the Spring (Fall) tomato crop lasts for 11 (6) weeks, from mid-April to early in July (mid-November to the last week of December). The growing season ends in the first week of July (late in December) by cleaning up the greenhouses and removing the plants. The average Spring (Fall) yield is 3534 (1767) pounds per week. On average, 2160 (2160) plants are grown in the greenhouse module. The average production is 38874 (10602) pounds. The total annual greenhouse tomato production is 49476 per greenhouse module. Table 16 (17) shows the total production costs and the operating schedule of the greenhouse tomato production in the Spring (Fall) season.

Cucumber Production

For the Spring (Fall) crop, cucumber seeds are sown early in December (early in August). Time from seedlings to pricking out into 4 inch pots is 10 days. Prior to pricking out, seedlings in pearlite medium are placed in 4 inch bottomless pots. One cucumber plant is placed in each bag with the bags spaced 16 to 18 inches apart in a row early in February (the second week of September). Watering and fertilizing in the Spring (Fall) season last for 21 (16) weeks, from the first week of February to the first week of July (the first week of September to the last week of December). A complete nutrient solution is fed through a plastic spray stake in each bag, at a flow rate of about 0.1 GPM. Nutrient solution is applied several times a day,

TABLE 16

THE PRODUCTION COSTS FOR PRODUCING A TOMATO SPRING CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Operation inputs	Unt	Amt	$/unt	$Total
Natural Gas	mcf	864.00	2.25	1944.00
Electricity	mo	8.00	160.00	1280.00
Clips, 1", (3000/case)	case	9.00	61.00	549.00
Tomato Twine	reel	3.00	67.25	201.75
Seeds	seed	2160.00	0.095	205.20
Pots	pot	2160.00	0.06	129.66
Black poly bags	bag	2160.00	0.18	388.80
Medium	cft	96.00	2.23	214.08
Insecticides	bag	5.00	36.00	180.00
Subtotal	$			5092.43

Months	Operation Schedule	$Total
December 1-15		
	Plant seeds in flats	15.00
	Watering	1.55
	Seedlings Pricked out into 4" Pots.	37.50
15-31		
	Watering	1.55
	Seedlings Pricked out into 4" Pots.	37.50
January 1-31		
	Watering	3.10
February 1-28		
	Bag Preparation & Filling	90.00
	Transplanting in greenhouse beds	125.00
	Watering and Fertilizing	175.51
	Stringing & Pruning (4th week)	110.00
March 1-15		
	Pollination (1st week)	130.00
	Watering and Fertilizing	87.76
	Stringing & Pruning	220.00

TABLE 16 (Continued)

Months	Operation Schedule	$Total
	Disease control (1st week)	5.00
15-31		
	Pollination	130.00
	Watering and Fertilizing	87.76
	Stringing & Pruning	220.00
	Disease control	5.00
April 1-15		
	Disease control	5.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	93.88
	Pollination	130.00
15-30		
	Start harvesting (3rd week)	270.00
	Watering and Fertilizing	93.88
	Pollination	130.00
	Stringing & Pruning	220.00
	Disease control	5.00
May 1-31		
	Harvesting	540.00
	Stringing and Pruning (up to 3rd week)	330.00
	Watering and Fertilizing	187.77
	Pollination (up to 3rd week)	195.00
	Disease control	10.00
June 1-30		
	Harvesting	540.00
	Watering and Fertilizing	187.77
	Disease control	10.00
July 1-7		
	Disease control	2.50
	Watering and Fertilizing	48.31
	End harvesting	135.00
	Clean up house and remove plants	120.00
	Management charge	4101.21

TABLE 16 (Continued)

Months	Operation Schedule	$Total
	Subtotal	9057.54
	Interest on operating capital	849.00
	Total Spring Production costs	14998.96

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

Cooperative Extension Service. Division of Agriculture, OSU. Department of Agriculture Economics, 1990.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Personal Contact With OSU Greenhouse Vegetable Extension Experts, 1991.

TABLE 17

THE PRODUCTION COSTS FOR PRODUCING A TOMATO FALL CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Operation inputs	Unt	Amt	$/unt	$Total
Natural Gas	mcf	216.00	2.25	486.00
Electricity	mo	4.00	240.00	960.00
Clips, 1", (3000/case)	case	9.00	61.00	549.00
Tomato Twine	reel	3.00	67.25	201.75
Seeds	seed	2160.00	0.095	205.20
Pots	pot	2160.00	0.06	129.60
Medium	cft	96.00	2.23	214.08
Insecticides	bag	3.50	36.00	126.00
Subtotal	$			2871.63

Months	Operation Schedule	$Total
August 1-15		
	Plant seeds in flats	15.00
	Watering	1.06
	Seedlings Pricked out into 4" Pots.	37.50
15-31		
	Watering	1.06
	Seedlings Pricked out into 4" Pots.	37.50
September 1-15		
	Bag Preparation & Filling	90.00
	Transplanting in greenhouse beds (2nd week)	125.00
	Watering and Fertilizing	157.85
October 1-15		
	Stringing & Pruning (1st week)	220.00
	Pollination (2nd week)	65.00
	Watering and Fertilizing	78.92
	Disease control (2nd week)	2.50
15-31		
	Pollination	130.00
	Watering and Fertilizing	78.92

TABLE 17 (Continued)

Months	Operation Schedule	$Total
	Stringing & Pruning	220.00
	Disease control	5.00
November 1-15		
	Pollination	130.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	89.18
	Disease control	5.00
15-30		
	Watering and Fertilizing	89.18
	Disease control	5.00
	Start harvesting (3rd week)	135.00
December 1-30		
	Harvesting	270.00
	Watering and Fertilizing	178.37
	Disease control	10.00
	Clean up house and remove plants	120.00
	Management charge	1118.51
	Subtotal	3635.56
	Interest on operating capital	390.43
	Total Fall Production costs	6897.62

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

Cooperative Extension Service. Division of Agriculture, OSU. Department of Agriculture Economics, 1990.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Personal Contact With OSU Greenhouse Vegetable Extension Experts, 1991.

depending on temperature and cucumber plant size. The cucumber plants can be grown with complete nutrient solution alone, with a complete N-P-K slow release fertilizer, or with a combination of the two materials. Rates for the material should be reduced to 30 to 40 percent when used in combination. The irrigation volume required varies from 1 to 4 quarts per plant per day. At each irrigation, a sufficient volume of solution should be applied to wet all the growing medium particles in the plant root zone (Johnson and Hickman). The total of 62000 (42500) gallons of water is used (Table 18).

During the Spring (Fall) season, stringing and pruning lasts for 12 (6) weeks, from the last week of February to the third week of May (the first week of October to mid-November). Disease control starts 3-4 weeks after transplanting seedlings in the greenhouse beds all through to the end of the season.

Harvesting the Spring (Fall) cucumber crop starts from the last week of March to the first week of July (the first week of November to the last week of December), that is 14 (8) weeks. The growing season ends in the first week of July (late in December) by cleaning up the greenhouses and removing the plants. The average Spring (Fall) yield is 2070 (4140) pounds per week. On average, 1440 (1440) plants are grown in the greenhouse module. The average production is 28980 (33120) pounds. The total annual greenhouse cucumber production is 62100 pounds. Table 19 (20) shows the total production costs and the operating schedule

TABLE 18

WATERING AND FERTILIZING REQUIREMENTS OF CUCUMBER PRODUCTION/MODULE: THE BAG CULTURE PRODUCTION SYSTEM

		Spring Season		Fall Season	
Item	Unit	Quantity	$Cost	Quantity	$Cost
Water	gal	62000.00	62.00	42500.00	42.50
Fertilizer					
Seedlings to first fruit set					
Magnesium Sulphate	lb	31.00	13.64	62.00	27.28
Monopotassium (0-22.5-28)	lb	16.50	4.95	33.00	9.90
Potassium Nitrate (13-0-44)	lb	12.50	3.88	25.00	7.75
Calcium Nitrate	lb	42.00	13.02	84.00	26.04
Chelated Iron	lb	1.50	4.38	3.00	8.76
Micro-Nutrient	lb	0.15	0.17	0.30	0.33
Fruit set to crop termination					
Magnesium Sulphate	lb	53.00	23.32	106.00	46.64
Monopotassium (0-22.5-28)	lb	28.50	8.55	57.00	17.10
Potassium Nitrate (13-0-44)	lb	12.25	6.59	42.50	13.18
Calcium Nitrate	lb	144.50	44.80	289.00	89.59
Chelated Iron	lb	2.50	7.30	5.00	14.60
Micro-Nutrient	lb	0.25	0.28	0.50	0.56
Total Fertilizer	lb	353.65	130.86	707.30	261.72
Total	$		192.86		304.22

Sources:

Hochmuth, G (Ed). Florida: Greenhouse Vegetable Production Handbook (3), 1991

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

TABLE 19

THE PRODUCTION COSTS FOR PRODUCING A CUCUMBER SPRING CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Operation inputs	Unt	Amt	$/unt	$Total
Natural Gas	mcf	864.00	2.25	1944.00
Electricity	mo	8.00	160.50	1280.00
Clips, 1", (3000/case)	case	9.00	61.00	549.00
Cucumber Twine	reel	3.00	67.25	201.75
Seeds	seed	1440.00	0.45	648.00
Pots	pot	1440.00	0.06	86.40
Black poly bags	bag	1440.00	0.18	259.20
Medium	cft	96.00	2.23	214.08
Insecticides	bag	5.00	36.00	180.00
Subtotal	$			5362.43

Months	Operation Schedule	$Total
December 1-15		
	Plant seeds in flats	15.00
	Watering	1.55
	Seedlings Pricked out into 4" Pots.	37.50
15-31		
	Watering	1.55
	Seedlings Pricked out into 4" Pots.	37.50
January 1-31		
	Watering	3.10
February 1-28		
	Bag Preparation & Filling	90.00
	Transplanting in greenhouse beds	125.00
	Watering and Fertilizing	150.65
	Stringing & Pruning (4th week)	110.00
March 1-15		
	Watering and Fertilizing	75.33
	Stringing & Pruning	220.00
	Disease control (1st week)	5.00

TABLE 19 (Continued)

Months	Operation Schedule	$Total
15-31		
	Watering and Fertilizing	75.33
	Stringing & Pruning	220.00
	Disease control	5.00
	Start harvesting (4th week)	67.50
April 1-15		
	Harvesting	135.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	79.29
	Disease control	5.00
15-30		
	Harvesting	135.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	79.29
	Disease control	5.00
May 1-15		
	Harvesting	135.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	79.29
	Disease control	5.00
15-31		
	Harvesting	135.00
	Stringing & Pruning (up to 3rd week)	110.00
	Watering and Fertilizing	79.29
	Disease control	5.00
June 1-30		
	Harvesting	270.00
	Watering and Fertilizing	158.57
	Disease control	10.00
July 1-7		
	Harvesting	67.50
	Watering and Fertilizing	39.64
	Disease control	2.50
	Clean up house and remove plants	120.00

TABLE 19 (Continued)

Months	Operation Schedule	$Total
	Management charge	2782.08
	Subtotal	6337.44
	Interest on operating capital	701.99
	Total Spring Production costs	12401.86

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

Cooperative Extension Service. Division of Agriculture, OSU. Department of Agriculture Economics, 1990.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Personal Contact With OSU Greenhouse Vegetable Extension Experts, 1991.

TABLE 20

THE PRODUCTION COSTS FOR PRODUCING A CUCUMBER FALL CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Operation inputs	Unt	Amt	$/unt	$Total
Natural Gas	mcf	216.00	2.25	486.00
Electricity	mo	4.00	240.00	960.00
Clips, 1", (3000/case)	case	9.00	61.00	549.00
Cucumber Twine	reel	3.00	67.25	201.75
Seeds	seed	1440.00	0.45	648.00
Pots	pot	1440.00	0.06	86.40
Medium	cft	96.00	2.23	214.08
Insecticides	bag	3.50	36.00	126.00
Subtotal	$			3271.23

Months	Operation Schedule	$Total
August 1-15		
	Plant seeds in flats	15.00
	Watering	1.06
	Seedlings Pricked out into 4" Pots.	37.50
15-31		
	Watering	1.06
	Seedlings Pricked out into 4" Pots.	37.50
September 1-30		
	Bag Preparation & Filling	90.00
	Transplanting in greenhouse beds (2nd week)	125.00
	Watering and Fertilizing	179.78
October 1-15		
	Watering and Fertilizing	89.89
	Stringing & Pruning (1st week)	220.00
	Disease control (2nd week)	2.50
15-31		
	Watering and Fertilizing	89.89
	Stringing & Pruning	220.00
	Disease control	5.00

TABLE 20 (Continued)

Months	Operation Schedule	$Total
November 1-15		
	Start harvesting	270.00
	Stringing & Pruning	220.00
	Watering and Fertilizing	105.63
	Disease control	5.00
15-30		
	Watering and Fertilizing	105.63
	Disease control	5.00
	Harvesting	270.00
December 1-15		
	Harvesting	270.00
	Watering and Fertilizing	105.63
	Disease control	5.00
15-31		
	Harvesting	270.00
	Watering and Fertilizing	105.63
	Disease control	5.00
	Clean up house and remove plants	120.00
	Management charge	3179.52
	Subtotal	6156.24
	Interest on operating capital	565.65
	Total Fall Production costs	9993.12

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

Cooperative Extension Service. Division of Agriculture, OSU. Department of Agriculture Economics, 1990.

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Personal Contact With OSU Greenhouse Vegetable Extension Experts, 1991.

for the greenhouse cucumber production in the Spring (Fall) season.

Labor Cost

The season of either tomatoes or cucumbers begins with sowing of seed and nurturing of seedlings before they are ready for transplanting. Plants are transplanted and placed in readily prepared bags which contain pearlite medium. Then, they are placed in permanent beds. Watering, fertilizing, stringing , pruning, and pollinating (tomatoes only) are performed continuously. Harvesting activities are carried out two or three times a week. The season ends with the cleaning of the greenhouse and removing the plants. The average labor requirement for producing tomatoes varies from 5-60 (5-38) hours per week in the Spring (Fall) season per greenhouse module, whereas the average labor requirement for producing cucumbers varies from 5-42 (5-45) hours in the Spring (Fall) season per week per greenhouse module. The average wage rate is assumed to be $ 5.00 per hour. The difference between the average labor requirement of producing the two crops is attributed mainly to the fact that pollinating activity is not required for cucumber production. Tables 21, 22, 23 and 24 show the total labor requirements and costs for both tomato and cucumber production in the Spring and the Fall seasons.

Marketing Cost

Most of the greenhouse tomato (cucumber) production is

TABLE 21

LABOR REQUIREMENTS FOR PRODUCING A SPRING TOMATO CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Activity	Unit	Amt	Week	$Total
Growing Seedlings	hr	3.00	1.00	15.00
Growing Transplants	hr	15.00	once/ses	75.00
Bag preparation & filling	hr	18.00	once/ses	90.00
Transplanting	hr	25.00	once/ses	125.00
Stringing and Pruning[1]	hr	264.00	12.00	1320.00
Pollinating[1]	hr	143.00	11.00	715.00
Watering and fertilizing	hr	126.00	21.00	630.00
Harvesting and Packing[1]	hr	297.00	11.00	1485.10
Disease control	hr	8.50	17.00	42.50
Removal of plants and House clean up	hr	24.00	season	120.00
Total	hr	923.50		
Total	$			4617.50

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

1 Personal contact with Oklahoma greenhouse operators, Nov 1991.

TABLE 22

LABOR REQUIREMENTS FOR PRODUCING A FALL TOMATO CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Activity	Unit	Amt	Week	$Total
Growing Seedlings	hr	3.00	1.00	15.00
Growing Transplants	hr	15.00	once/ses	75.00
Bag preparation & filling	hr	18.00	once/ses	90.00
Transplanting	hr	25.00	once/ses	125.00
Stringing and Pruning[1]	hr	132.00	6.00	660.00
Pollinating[1]	hr	65.00	5.00	325.00
Watering and fertilizing	hr	96.00	16.00	480.00
Harvesting and Packing[1]	hr	81.00	6.00	405.00
Disease control	hr	5.50	11.00	27.50
Removal of plants and House clean up	hr	24.00	season	120.00
Total	hr	464.50		
Total	$			2322.50

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

1 Personal contact with Oklahoma greenhouse operators, Nov 1991.

TABLE 23

LABOR REQUIREMENTS FOR PRODUCING A SPRING CUCUMBER CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Activity	Unit	Amt	Week	$Total
Growing Seedlings	hr	3.00	1.00	15.00
Growing Transplants	hr	15.00	once/ses	75.00
Bag preparation & filling	hr	18.00	once/ses	90.00
Transplanting	hr	25.00	once/ses	125.00
Stringing and Pruning[1]	hr	264.00	12.00	1320.00
Watering and fertilizing	hr	126.00	21.00	630.00
Harvesting and Packing[1]	hr	189.00	14.00	945.00
Disease control	hr	8.50	17.00	42.50
Removal of plants and House clean up	hr	24.00	season	120.00
Total	hr	672.50		
Total	$			3362.50

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

1 Personal contact with Oklahoma greenhouse operators, Nov 1991.

TABLE 24

LABOR REQUIREMENTS FOR PRODUCING A FALL CUCUMBER CROP, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Activity	Unit	Amt	Week	$Total
Growing Seedlings	hr	3.00	1.00	15.00
Growing Transplants	hr	15.00	once/ses	75.50
Bag preparation & filling	hr	18.00	once/ses	90.00
Transplanting	hr	25.00	once/ses	125.00
Stringing and Pruning[1]	hr	132.00	6.00	660.00
Watering and fertilizing	hr	96.00	16.00	480.00
Harvesting and Packing[1]	hr	216.00	8.00	1080.00
Disease control	hr	5.50	11.00	27.50
Removal of plants and House clean up	hr	24.00	season	120.00
Total	hr	534.50		
Total	$			2672.50

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

1 Personal contact with Oklahoma greenhouse operators, Nov 1991.

sold by the growers to nearby wholesalers. The marketed tomatoes required an average of two trips per week. Tomatoes are sorted into two grades, grade one and grade two or unclassified. About ninety percent of the total produce is packed in ten pound boxes as grade one tomatoes and the other ten percent is sold as grade two tomatoes or unclassified and packed in twenty pound boxes. Accordingly, the prices of the greenhouse tomatoes vary with grades. The average wholesale prices are $1.10 per pound of the grade one tomatoes and $0.65 per pound of unclassified tomatoes. The marketed cucumbers also required an average of two trips per week, with an average wholesale price of $0.96 per pound of cucumbers (McCraw). Tables 25, 26, 27 and 28 show the breakdown and the total annual marketing cost for the greenhouse tomatoes and cucumbers for both the bed culture and the bag culture production systems.

Annual Total Return Per Module

Table 29 (30) shows that the total annual variable costs required to produce tomatoes (cucumbers), $25042.91 ($31309.46), are subtracted from the total annual tomato (cucumber) sales, $52197.18 ($59616.00), to give the return above the variable costs of $27154.27 ($28306.54) or about $3.14 ($3.28) per square feet of the greenhouse module. However, the return above all costs but risk is $18503.29 ($19655.56) or about $2.14 ($2.27) per square feet of the greenhouse module.

Based on these results, greenhouse cucumber production

TABLE 25

MARKETING COST FOR SPRING/FALL WHOLESALING GREENHOUSE TOMATOES, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

			Spring season		Fall season	
Item	Unt	$/unt	Amt	$Total	Amt	$Total
Packing Box[1]						
Grade 1	box	0.45	3110.00	1399.50	848.00	381.60
Grade 2	box	0.65	173.00	112.45	47.00	30.55
Delivery Truck	trip	5.50	20.00	110.00	12.00	66.00
Delivery Labor	hr	5.00	30.00	150.00	12.00	60.00
Total	$			1771.95		538.15

1 Personal contact with Oklahoma greenhouse operators, Nov 1991.

TABLE 26

MARKETING COST FOR SPRING/FALL WHOLESALING GREENHOUSE CUCUMBERS, 8640 SQUARE FEET GREENHOUSE MODULE THE BED CULTURE PRODUCTION SYSTEM

			Spring season		Fall season	
Item	Unt	$/unt	Amt	$Total	Amt	$Total
Wrapping[1] & Boxing	box	1.83	1500.00	2745.00	1700.00	3111.00
Delivery Labor	hr	5.00	26.00	130.00	24.00	120.00
Delivery Truck	trip	5.50	26.00	143.00	16.00	88.00
Other services	hr	5.00	39.00	195.00	28.00	140.00
Total	$			3213.00		3459.00

1 Hickman, G. W. and Klonsky, K. Cost of production and Equipment in San Joaquin Valley, 1986.

TABLE 27

MARKETING COST FOR SPRING/FALL WHOLESALING GREENHOUSE TOMATOES, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

			Spring season		Fall season	
Item	Unt	$/unt	Amt	$Total	Amt	$Total
Packing Box[1]						
Grade 1	box	0.45	3500.00	1575.00	954.00	429.30
Grade 2	box	0.65	194.00	126.10	53.00	34.45
Delivery Truck	trip	5.50	20.00	110.00	12.00	66.00
Delivery Labor	hr	5.00	30.00	150.00	12.00	60.00
Total	$			1961.10		589.75

1 Personal contact with Oklahoma greenhouse operators, Nov 1991.

TABLE 28

MARKETING COST FOR SPRING/FALL WHOLESALING GREENHOUSE CUCUMBERS, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

			Spring season		Fall season	
Item	Unt	$/unt	Amt	$Total	Amt	$Total
Wrapping[1] & Boxing	box	1.83	1900.00	3477.00	2200.00	4026.00
Delivery Labor	hr	5.00	26.00	130.00	24.00	120.00
Delivery Truck	trip	5.50	26.00	143.00	16.00	88.00
Other services	hr	5.00	39.00	195.00	28.00	140.00
Total	$			3945.00		4374.00

1 Hickman, G. W. and Klonsky, K. Cost of production and Equipment in San Joaquin Valley, 1986.

TABLE 29

ANNUAL TOTAL RETURN AND BREAK EVEN COST/MODULE, TOMATO PRODUCTION: THE BAG CULTURE PRODUCTION SYSTEM

	Unt	$Amt
Total Revenue	$ per module	52197.18
Revenue	$ per sq. ft.	6.04
Total Variable Costs	$ per module	25042.91
Variable Costs	$ per sq. ft.	2.90
Return above Variable Costs	$ per module	27154.27
Return above Variable Costs	$ per sq. ft.	3.14
Total Costs	$ per module	33693.89
Total Costs	$ per sq. ft.	3.90
Net Profit	$ per module	18503.29
Net Profit	$ per sq. ft.	2.14
Total Production	pounds	49476.00
Break even cost	$ per pound	0.68

TABLE 30

ANNUAL TOTAL RETURN AND BREAK EVEN COST/MODULE, CUCUMBER PRODUCTION: THE BAG CULTURE PRODUCTION SYSTEM

	Unt	$Amt
Total Revenue	$ per module	59616.00
Revenue	$ per sq. ft.	6.90
Total Variable Costs	$ per module	31309.46
Variable Costs	$ per sq. ft.	3.62
Return above Variable Costs	$ per module	28306.54
Return above Variable Costs	$ per sq. ft.	3.28
Total Costs	$ per module	39960.44
Total Costs	$ per sq. ft.	4.63
Net Profit	$ per module	19655.56
Net Profit	$ per sq. ft.	2.27
Total Production	pounds	62100.00
Break even cost	$ per pound	0.64

using the bag culture production system is more attractive than greenhouse tomato production to the investors of the greenhouse industry.

Break Even Cost

Table 29 (30) shows a summary of the break even cost. If tomato (cucumber) total fixed and variable costs of $33693.89 ($39960.44) are divided by the annual total tomato (cucumber) production of 49476 (62100) pounds, the break even tomato (cucumber) production cost is $.68 ($.64) per pound. In other words, the production costs for greenhouse tomato (cucumber) averaged over $.68 ($.64) per pound, assuming the average Spring (Fall) tomato yield of 3534 (1767) pounds per week, and the average of 2070 (4140) pounds per week in the Spring (Fall) cucumber production. Thus, the bed culture greenhouse tomato (cucumber) production is a break even operation if the produced crop is sold at $.68 ($.64) per pound.

Recirculating Hydroponic Culture Production System

Recirculating hydroponic culture involves the production of plants either (1) in a solid inert material such as gravel, perlite or cinders supplied with a solution encompassing water and the essential nutrient elements, or (2) in a water solution without an inert material. Successful plant production using this means necessitates constantly providing an adequate supply of the essential elements in the solution (Brooks).

Tomato Production

The third common greenhouse production system in Oklahoma is the use of the piping production system to grow a one-crop tomato production each year where the operating schedule begins late in summer by sowing the tomato seeds and ends late in the following June or early July by cleaning up the house and removing the plants. Seedlings will emerge in 8-10 days and need to be moistened with a dilute nutrient solution until they are ready to be transplanted. Transplants 4-6 inches tall are ready to be grown in the growing tubes in the greenhouse early in September. Seedlings are placed in the pipes and the nutrient flow started.

In a recirculating hydroponic system, the final nutrient solution is usually formulated in a large sump tank by mixing sufficient fertilizer solution from the stocks to fulfill the proper concentrations of the various nutrients. The solution from the sump tank is circulated through the pipes in the greenhouse that contain the root system of the crop. The piping system in the greenhouse must be sized correctly to deliver sufficient solution to the pipes during peak demand periods. Plants need to be inspected for insects and diseases that might damage the entire crop if not controlled properly. In Oklahoma, canker is one of the major disease problems that faces greenhouse growers. The disease is spread to some extent through the re-circulating of the nutrient solution. One of the greenhouse growers states that depending on the severity of the disease problems, there may be partial crop failure in 3 out of 4 years of crop production.

Pollination at least every other day begins as soon as flowers appear, usually about 75-80 days from seeding, and ends 40-45 days prior to the crop termination. Tomatoes are self-pollinated. That is, pollen from a flower pollinates the same flower. Pollination is achieved by vibrating the flower cluster for a second or two with a battery-operated vibrator.

Greenhouse tomatoes require pruning of all suckers once they are 2-3 inches tall twice a week. Plants are clipped once they reach 12-15 inches in height and start to tip and are topped at 40-45 days prior to crop termination. In the piping system, the roots need clipping at least once a week.

Harvesting the crop lasts for eight months. It starts late in October and continues through the winter and until late in June or early in July, depending on the market situation. The average tomato yield is about 10 pounds per plant in the winter months and 15-20 pounds per plant in the proceeding months. At the end of the production period, the roots in the pipes are removed and the pipes cleaned. Most of the growers prefer to have at least one month between crops for cleaning the house and preparation for the new crop (Hochmuth).

The Annual Cash Flow

Tomato Production

Table 31 (32) shows the tomato crop annual cash flow using the bed culture (the bag culture) production system. The cash inflow shows the total annual tomato crop sales. The sales occur from mid-April to early in July in the Spring season, with an average sale of $3314.81 ($3728.37) per week. Then, they occur from mid-November to the last week of December in the Fall season, with an average sale of $1657.41 ($1864.19) per week.

The cash outflow, however, consists of four elements. These elements are the operating input costs, the hired labor cost, the marketing cost, and the other cash outflow costs.

The Operating Input Costs

In Oklahoma, natural gas is the fuel used for the greenhouse heating system. The consumption of natural gas varies through the year in the tomato greenhouse using both systems. It reaches its peak in January and February when the weather is the coolest. The average monthly fuel cost during these two months is $405. However, heating costs are $0 in July and August when the weather is the hottest. The total annual consumption of natural gas is 1080 thousand cubic feet, with an average cost of $2.25 per thousand cubic feet.

Electricity is used for the cooling system and

TABLE 31

THE ANNUAL CASH FLOW FOR PRODUCING TOMATO SPRING & FALL CROPS, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Operating Receipts													
Crop Sales				6629.62	13259.24	13259.24	3314.81				3314.81	6629.62	46407.34
The operating input costs													
Natural Gas	405.00	405.00	324.00	243.00	162.00	81.00	0.00	0.00	81.00	162.00	243.00	324.00	2430.00
Electricity	53.33	53.33	106.67	160.00	213.33	266.67	320.00	320.00	266.67	213.33	160.00	106.67	2240.00
Clips		47.75	183.00	183.00	137.25					366.00	183.00		1098.00
Tomato Twine		16.81	67.25	67.25	50.44					134.50	67.25		403.50
Seeds								205.20				205.20	410.40
Pots								129.60				129.60	259.20
Medium								214.08				214.08	428.16
Insecticides			42.35	42.35	42.35	42.35	10.59			34.26	45.82	45.82	306.00
Water	3.10	7.75	7.75	12.40	12.40	12.40	3.10	2.13	7.44	7.44	12.75	15.85	104.50
Fertilizer		92.88	92.88	106.15	106.15	106.15	26.54		53.07	53.07	79.61	79.61	796.10
The hired labor cost													
Growing Seedlings								15.00				15.00	30.00
Growing Transplants								75.00				75.00	150.00
Transplanting		125.00							125.00				250.00
Stringing & Pruning		110.00	440.00	440.00	330.00					440.00	220.00		1980.00

TABLE 31 (Continued)

Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
<u>The hired labor cost</u>													
Pollination			260.00	260.00	195.00					195.00	130.00		1040.00
Watering and Fertilizing		120.00	120.00	120.00	120.00	120.00	30.00		120.00	120.00	120.00	120.00	1110.00
Harvesting and Packing				270.00	540.00	540.00	135.00				135.00	270.00	1890.00
Disease control			10.00	10.00	10.00	10.00	2.50			7.50	10.00	10.00	70.00
Removal of Plants and House Cleanup							120.00					120.00	240.00
Delivery				27.26	54.55	54.55	13.64				20.00	40.00	210.00
<u>The market cost</u>													
Packing Boxes				274.90	549.80	549.80	137.45				137.38	274.77	1924.10
Delivery Truck				20.00	40.00	40.00	10.00				22.00	44.00	176.00
<u>The other cash flow costs</u>													
Management charge							3646.29					994.44	4640.73
Interest on operating capital (0.06)							808.21					384.443	1192.60
Property Taxes (0.16)												830.45	830.45
Insurance (0.008)												415.23	415.23
Repair (0.02)												470.92	470.92
Total Cash Outflow	461.43	976.52	1653.90	2236.32	2563.27	1822.91	5263.31	961.01	653.18	1733.21	1585.81	13265.77	25095.88
Inflow - Outflow	-461.43	-976.52	-1653.90	4393.30	10695.97	11436.33	-1948.50	-961.01	-653.18	-1733.21	1729.00	-6636.15	21311.46

TABLE 32

THE ANNUAL CASH FLOW FOR PRODUCING TOMATO SPRING & FALL CROPS, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
<u>Operating Receipts</u>													
Crop Sales				7456.74	14913.48	14913.48	3728.37				3728.37	7456.74	52197.18
<u>The operating input costs</u>													
Natural Gas	405.00	405.00	324.00	243.00	162.00	81.00	0.00	0.00	81.00	162.00	243.00	324.00	2430.00
Electricity	53.33	53.33	106.67	160.00	213.33	266.67	320.00	320.00	266.67	213.33	160.00	106.67	2240.00
Clips		47.75	183.00	183.00	137.25					366.00	183.00		1098.00
Tomato Twine		16.81	67.25	67.25	50.44					134.50	67.25		403.50
Seeds								205.20				205.20	410.40
Pots								129.60				129.60	259.20
Poly Bags		388.80											388.80
Medium								214.08				214.08	428.16
Insecticides			42.35	42.35	42.35	42.35	10.59			34.26	45.82	45.82	306.00
Water	3.10	7.75	7.75	12.40	12.40	12.40	3.10	2.13	7.44	7.44	12.75	15.85	104.50
Fertilizer		53.22	53.22	60.82	60.82	60.82	15.21		30.41	30.41	45.62	45.62	456.15
<u>The hired labor cost</u>													
Growing Seedlings								15.00				15.00	30.00
Growing Transplants								75.00				75.00	150.00
Transplanting		125.00							125.00				250.00

TABLE 32 (Continued)

Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
<u>The hired labor cost</u>													
Bag preparation & filling		90.00							90.00				180.00
Stringing & Pruning		110.00	440.00	440.00	330.00					440.00	220.00		1980.00
Pollination			260.00	260.00	195.00					195.00	130.00		1040.00
Watering and Fertilizing		120.00	120.00	120.00	120.00	120.00	30.00		120.00	120.00	120.00	120.00	1110.00
Harvesting and Packing				270.00	540.00	540.00	135.00				135.00	270.00	1890.00
Disease control			10.00	10.00	10.00	10.00	2.50			7.50	10.00	10.00	70.00
Remove of plants and House Cleanup							120.00					120.00	240.00
Delivery				27.27	54.55	54.55	13.64				20.00	40.00	210.00
<u>The market cost</u>													
Packing Boxes				309.29	618.58	618.58	154.65				154.65	309.17	2164.85
Delivery Truck				20.00	40.00	40.00	10.00				22.00	44.00	176.00
<u>The other cash flow costs</u>													
Managment charge							4101.21					1118.51	5219.72
Interest on operating capital (0.06)							849.00					390.43	1239.43
Property Taxes (0.016)												817.13	817.13
Insurance (0.008)												408.57	408.57
Repair (0.02)												595.47	595.47
Total Cash Outflow	461.43	1415.66	1614.24	2225.39	2586.72	1846.37	5764.88	961.01	720.51	1710.54	1569.02	12845.39	26295.88
Inflow - Outflow	-461.43	-1415.66	-1614.24	5231.35	12326.76	13067.11	-2036.51	-961.01	-720.51	-1710.54	2159.35	-5388.65	25901.30

lighting. Just opposite to the need for natural gas, the need for electricity in tomato greenhouse reaches its peak in July and August when $320 is the required monthly bill, and it reaches the lowest usage in January and February when $53.33 is the required monthly bill (McCraw).

Tomato seeds, pots, and medium are purchased early in December in the Spring season and early in August in the Fall season for both production systems. About 2160 pots, 2160 seeds, and 96 cubic feet of medium are required per greenhouse module per season, with an average cost of $6 /100 pots, $95 /1000 seeds, and $2.23 /cubic feet of medium.

Clips, tomato twine, and insecticides are purchased at the time of stringing, pruning, and disease control. The required amounts per greenhouse module are 18 clip cases, 6 twine reels, and 8.5 insecticide bags, at an average cost of $61, $67.25, and $36, respectively.

Water usage increases as the season moves ahead since the young tomato plants require less water than the old plants (Lamont and Marr). The total water usage is 62000 gallons in the Spring season, and 42500 gallons in the Fall season, with an average water cost of $1 /1000 gallons.

Using the bed culture (the bag culture) production system, fertilizer usage increases as the tomato growing season progresses. It starts from the first week of February to the first week of July in the Spring season, and from the first week of September to late in December in the Fall season. About 1209 (789.6) pounds of fertilizer are required in the Spring season with an average cost of $.44

per pound, and 604.5 (394.8) pounds in the Fall season, with an average fertilizer cost of $.38 per pound in the Fall season.

Polybags are required if the bag culture production system is used. A total of 2160 bags are purchased once a year in February since they are used in both seasons, with an average cost of $18/100 bags.

The Hired Labor Cost

Labor is hired to perform certain activities including transplanting, stringing, pruning, pollinating, watering, fertilizing, harvesting, disease control, and cleaning the greenhouse at the end of the tomato growing seasons.

Using both production systems, sowing tomato seeds and nurturing of seedlings are performed early in December and early in August. Transplanting the tomato plants in the greenhouse beds is carried out early in February and in the second week of September. The average of 3 hours, 15 hours, and 25 hours, respectively, is required to grow seedlings, grow transplants, and transplant plants per greenhouse module per season, with an average cost of $5 per hour.

Stringing and pruning the tomato plants are performed from the last week of February to the third week of May in the Spring season, and from the first week of October to mid-November in the Fall season. The average hours required to perform stringing and pruning are 22 per week per season, with an average cost of $5 per hour.

Using both production systems, watering and fertilizing are performed from the first week of February to the first week of July in the Spring season, and from the first week of September to late in December in the Fall season. The average hours required to perform watering and fertilizing per season are 6 hours per week, with an average cost of $5 per hour.

Harvesting the tomato crop starts in mid-April and continues to early in July in the Spring season, and from mid-November to the last week of December in the Fall season. The average harvesting hours are 27 per week in the Spring season, and 13.5 hours in the Fall season, with an average harvesting cost of $5 per hour.

Disease control is performed 3-4 weeks after transplanting seedlings in the greenhouse beds and continues throughout the season. The average weekly hours and cost per season are 0.5 hour and $5 per hour using both production systems.

Removal of tomato plants and cleaning the greenhouse are done in the first week of July in the Spring season and late in December in the Fall season. This requires 24 hours per greenhouse module per season, with an average cost of $5 per hour.

More activities are required if the bag culture production system is used. The activities include bag preparing and filling, which are performed early in February and early in September. They require 18 hours per greenhouse module per season, with an average cost of $5 per hour.

The Marketing Cost

Most of the tomatoes produced are sold to the nearby wholesale markets. In most cases, the crop is delivered to the markets after being packed according to its grade in a 10 and a 20 pound box. The cost of a 10 pound box averages $.45/box and $.65/box for a twenty pound box. Packing the crop requires 3958 (4454) ten pound boxes and 220 (247) twenty pound boxes using the bed culture (bag culture) production system. The average cost of delivering the crop to the market is $23.64 per week in the Spring season, and $21 per week in the Fall season. The delivery cost includes the delivery labor and operating cost for a truck. The tomato crop requires 2 trips and 3 hours of labor per week in the Spring season and 2 trips and 2 hours of labor per week in the Fall season, with an average cost of $5.5/trip and $5/hour. Marketing activities are performed on a weekly basis after harvesting.

The Other Cash Outflow Costs

Interest on annual operating capital is paid at end of the tomato growing seasons at a 12 percent interest rate. Property taxes, property insurance, repairs and maintenance are paid in December. Property tax is paid at 1.6 percent (Whittier and Fischer). Property insurance is paid at 0.8 percent. Repair and maintenance costs are paid at 2 percent of the costs of heating, cooling, ventilation, watering systems, and the minor equipment (Schatzer). The management charge is accounted for 10 percent of the annual crop sales.

Using the bed culture (bag culture) production system, when the cash outflow, $25095.88 ($26295.88), is subtracted from the cash inflow, $46407.34 ($52197.18), the annual cash flow is $21311.46 ($25901.30) or $2.47 ($3.00) per square feet of the greenhouse module.

Cucumber Production

Table 33 (34) shows the cucumber crop annual cash flow using the bed culture (the bag culture) production system. The cash inflow shows the total annual cucumber crop sales. The sale starts from the last week of March to early in July in the Spring season, with an average sale of $1555.2 ($1987.2) per week, and from the first week of November to the last week of December in the Fall season, with an average sale of $3110.4 ($3974.4) per week.

The cash outflow, however, consists of four elements. These elements are the operating input costs, the hired labor cost, the marketing cost, and the other cash outflow costs.

The Operating Input Costs

The consumption of natural gas required for the cucumber greenhouse reaches its peak in January and February. The average monthly fuel cost during these two months is $405. However, the fuel consumption for heating reaches $0 in July and August. The total annual natural gas usage is 1080 thousand cubic feet (mcf), with an average

TABLE 33

THE ANNUAL CASH FLOW FOR PRODUCING CUCUMBER SPRING & FALL CROPS, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
<u>Operating Receipts</u>													
Crop Sales			1555.20	6220.80	6220.80	6220.80	1555.20				12441.60	12441.60	46656.00
<u>The operating input costs</u>													
Natural Gas	405.00	405.00	324.00	243.00	162.00	81.00	0.00	0.00	81.00	162.00	243.00	324.00	2430.00
Electricity	53.33	53.33	106.67	160.00	213.33	266.67	320.00	320.00	266.67	213.33	160.00	106.67	2240.00
Clips		47.75	183.00	183.00	137.25					366.00	183.00		1098.00
Tomato Twine		16.81	67.25	67.25	50.44					134.50	67.25		403.50
Seeds								648.00				648.00	1296.00
Pots								86.40				86.40	172.80
Medium								214.08				214.08	428.16
Insecticides			42.35	42.35	42.35	42.35	10.59			34.26	45.82	45.82	306.00
Water	3.10	7.75	7.75	12.40	12.40	12.40	3.10	2.13	7.44	7.44	12.75	15.85	104.50
Fertilizer		22.90	22.90	26.17	26.17	26.17	6.54		52.34	52.34	78.52	78.52	392.58
<u>The hired labor cost</u>													
Growing Seedlings								15.00				15.00	30.00
Growing Transplants								75.00				75.00	150.00
Transplanting		125.00							125.00				250.00
Stringing & Pruning		110.00	440.00	440.00	330.00					440.00	220.00		1980.00

TABLE 33 (Continued)

Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
<u>The hired labor cost</u>													
Watering and Fertilizing		120.00	120.00	120.00	120.00	120.00	30.00		120.00	120.00	120.00	120.00	1110.00
Harvesting and Packing			67.50	270.00	270.00	270.00	67.50				540.00	540.00	2025.00
Disease control			10.00	10.00	10.00	10.00	2.50			7.50	10.00	10.00	70.00
Removal of Plants and House Cleanup							120.00					120.00	240.00
Delivery			9.29	37.14	37.14	9.29					60.00	60.00	250.00
<u>The market cost</u>													
Wrapping and Boxing			196.07	784.29	784.29	789.29	196.07				1555.50	1555.50	5856.00
Delivery Truck			10.21	40.86	40.86	40.86	10.21				44.00	44.00	231.00
Other services			13.93	55.71	55.71	55.71	13.93				70.00	70.00	335.00
<u>The other cash flow costs</u>													
Managment charge						2177.28						2488.32	4665.60
Interest on operating capital (0.06)							644.75					518.78	1163.53
Property Taxes (0.016)												830.45	830.45
Insurance (0.008)												415.23	415.23
Repair (0.02)												470.92	470.92
Total Cash Outflow	461.43	906.55	1620.92	1978.06	2926.06	1746.59	1183.85	1360.61	652.45	1537.48	3409.84	16933.28	28944.27
Inflow - Outflow	-461.43	-906.55	-65.72	4242.74	3294.74	4474.21	371.35	-1360.61	-652.45	-1537.48	9031.76	-4491.68	17711.73

TABLE 34

THE ANNUAL CASH FLOW FOR PRODUCING CUCUMBER SPRING & FALL CROPS, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
<u>Operating Receipts</u>													
Crop Sales			1987.20	7948.80	7948.80	7948.80	1987.20				15897.60	15897.60	59616.00
<u>The operating input costs</u>													
Natural Gas	405.00	405.00	324.00	243.00	162.00	81.00	0.00	0.00	81.00	162.00	243.00	324.00	2430.00
Electricity	53.33	53.33	106.67	160.00	213.33	266.67	320.00	320.00	266.67	213.33	160.00	106.67	2240.00
Clips		47.75	183.00	183.00	137.25					366.00	183.00		1098.00
Tomato Twine		16.81	67.25	67.25	50.44					134.50	67.25		403.50
Seeds								648.00				648.00	1296.00
Pots								86.40				85.40	172.80
Poly Bags		259.20											259.20
Medium								214.08				214.08	428.16
Insecticides			42.35	42.35	42.35	42.35	10.59			34.26	45.82	45.82	306.00
Water	3.10	7.75	7.75	12.40	12.40	12.40	3.10	2.13	7.44	7.44	12.75	15.85	104.50
Fertilizer		22.90	22.90	26.17	26.17	26.17	6.54		52.34	52.34	78.52	78.52	392.58
<u>The hired labor cost</u>													
Growing Seedlings								15.00				15.00	30.00
Growing Transplants								75.00				75.00	150.00
Transplanting		125.00							125.00				250.00

TABLE 34 (Continued)

Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
<u>The hired labor cost</u>													
Bag preparation & filling		90.00							90.00				180.00
Stringing & Pruning		110.00	440.00	440.00	330.00					440.00	220.00		1980.00
Watering and Fertilizing		120.00	120.00	120.00	120.00	120.00	30.00		120.00	120.00	120.00	120.00	1110.00
Harvesting and Packing			67.50	270.00	270.00	270.00	67.50				540.00	540.00	2025.00
Disease control			10.00	10.00	10.00	10.00	2.50			7.50	10.00	10.00	70.00
Removal of plants and House Cleanup							120.00					120.00	240.00
Delivery			9.29	37.14	37.14	37.14	9.29				60.00	60.00	250.00
<u>The market cost</u>													
Wrapping and Boxing			248.36	993.43	993.43	993.43	248.36				2013.00	2013.00	7503.00
Delivery Truck			10.21	40.86	40.86	40.86	10.21				44.00	44.00	231.00
Other services			13.93	55.71	55.71	55.71	13.93				70.00	70.00	335.00
<u>The other cash flow costs</u>													
Managment charge							2782.08					3179.52	5961.60
Interest on operating capital (0.06)							701.99					565.65	1267.64
Property Taxes (0.016)												817.13	817.13
Insurance (0.008)												408.57	408.57
Repair (0.02)												595.47	595.47

TABLE 34 (Continued)

Period	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Total
Total Cash Outflow	461.43	1255.75	1673.21	2701.32	2501.09	1955.73	1377.09	1360.61	742.45	1537.48	3867.34	17577.95	32535.16
Inflow - Outflow	-461.43	-1255.75	313.99	5247.48	5447.71	5993.07	610.11	-1360.61	-742.45	14360.12	12030.26	-1680.35	27080.84

cost of $2.25 per thousand cubic feet.

The need for electricity reaches its peak in July and August when $320 is the required monthly bill, and reaches the lowest usage in January and February when $53.33 is the cost per month.

In both production systems, cucumber seeds, pots, and medium are purchased early in December in the Spring season and early in August in the Fall season. On average, 1440 pots, 1440 seeds, and 96 cubic feet of medium are required per greenhouse module per season. The average cost is $6 per 100 pots, $45 per 100 seeds, and $2.23 per cubic feet of medium.

Clips, cucumber twine, and insecticides are purchased at the same time as stringing, pruning, and disease control. The required amounts of each item per greenhouse module are 18 clip cases, 6 twine reels, and 8.5 insecticide bags, with an average cost of $61/clip case, $67.25/twine reel, and $36 /insecticide bag.

The average water usage is 62000 gallons in the Spring season, and 42500 gallons in the Fall season, with an average cost of $1 per 1000 gallons. The fertilizer usage starts in early February and continues all through the Spring season, and early in September to late in December in the Fall season. About 1060.95 pounds of fertilizer are required annually for the greenhouse module in each production system, with an average cost of $.37 per pound.

Poly bags are purchased once a year early in February if the bag culture system is used. A total of 1440 bags, with an average cost of $18 per 100 bags, is required per greenhouse module.

The Hired Labor Cost

With the bed culture (bag culture) production system, sowing cucumber seeds and nurturing of seedlings are performed in early December and in early August. Transplanting cucumber plants in the greenhouse beds is performed early in February and in the second week of September. The average of 3 hours, 15 hours, and 25 hours is required to perform each of the above activities per greenhouse module per season, at an average cost of $5 per hour.

Stringing and pruning the cucumber plants are performed from the last week of February to the third week of May in the Spring season, and from the first week of October to mid-November in the Fall season. The average hours required to perform stringing and pruning are 22 hours per week per season, at an average cost of $5 per hour.

The watering and fertilizing activities are performed from the first week of February all through the Spring season, and from the first week of September to late in December in the Fall season. The total hours required to perform watering and fertilizing using each production system are 6 hours per week per season with an average cost of $5 per hour.

Harvesting the cucumber crop continues from the last week of March to the first week of July in the Spring season, and from the first week of November to the last week of December in the Fall season. The total harvesting hours are 13.5 per week during the Spring season, and 27 per week in the Fall season, with an average harvesting cost of $5 per hour.

Disease control is carried out 3-4 weeks after transplanting seedlings in the greenhouse beds and continues all through the season. The total disease control hours are .5 hour per week per season, with an average cost of $5 per hour.

Removal of cucumber plants and the cleanup of the greenhouse are done in the first week of July in the Spring season and late in December in the Fall season. They require 24 hours per season, with an average cost of $5 per hour.

More activities are required if the bag culture production system is used. Bag preparing and filling are performed early in February in the Spring season and early in September in the Fall season, and require 18 hours per season, at an average cost of $5 per hour.

The Marketing Cost

Most of the cucumbers produced are sold in nearby wholesale markets. In most cases the crop is delivered to the market after packing in 15 pounds boxes. The average cost of packing and boxing is $1.83 per box. Packing the crop requires 3200 (4100) boxes. On the other hand, delivering the crops averages $33.43 per week in the Spring season, and $43.50 per week in the Fall season. The delivery cost includes the delivery truck, delivery labor, and other services. The cucumbers produced require 2 trips, 2 labor hours, and 3 other service hours per week in the Spring season, and 2 trips, 3 labor hours, and 3.5 other service hours in the Fall season, with an average cost of $5.5/trip, $5/labor hour, and $5/other service hour.

The Other Cash Outflow Costs

Interest on annual operating capital is paid at the end of the cucumber growing seasons at a 12 percent interest rate. Property tax, property insurance, and repairs and maintenance are paid in December. Property tax, property insurance, and repairs and maintenance are paid at rates of 1.6, 0.8 and 2 percent, respectively. The management charge is accounted for 10 percent of the annual crop sales.

Using the bed culture (bag culture) production system, when the cash outflow, $28944.27 ($32535.16), is subtracted from the cash inflow, $46656 ($59616), the annual cash flow is $17711.73 ($27080.84) or $2.05 ($3.13) per square feet of the greenhouse module.

The Multi-Year Net Present Value

Table 35 (36) shows the computation of the net present value and the internal rate of return for the greenhouse tomato (cucumber) production investment using the bed culture production system. Table 37 (38) shows the computation of the net present value and the internal rate

TABLE 35

COMPUTATION OF NET PRESENT VALUE FOR GREENHOUSE TOMATO SPRING/FALL PRODUCTION, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Year	Capital Costs	Operating And Maintenance Costs	Total Costs	Discount Rate 0.12	Present Value 0.12	Total Revenue	Discount Rate 0.12	Present Value 0.12
0.00	51903.13		51903.13	1.00	51903.13		1.00	
1.00	4640.73	25095.88	29736.61	0.89	26550.55	46407.34	0.89	41435.13
2.00	11663.46	25095.88	36759.34	0.80	29304.32	46407.34	0.80	36995.65
3.00	4640.73	25095.88	29736.61	0.71	21165.93	46407.34	0.71	33031.83
4.00	11663.46	25095.88	36759.34	0.64	23361.23	46407.34	0.64	29492.70
5.00	7243.23	25095.88	32339.11	0.57	18350.08	46407.34	0.57	26332.77
6.00	11663.46	25095.88	36759.34	0.51	18623.43	46407.34	0.51	23511.40
7.00	4640.73	25095.88	29736.61	0.45	13451.33	46407.34	0.45	20992.32
8.00	11663.46	25095.88	36759.34	0.40	14846.48	46407.34	0.40	18743.15
9.00	4640.73	25095.88	29736.61	0.36	10723.32	46407.34	0.36	16734.95
10.00	22512.60	25095.88	47608.48	0.32	15328.66	46407.34	0.32	14941.92
11.00	4640.73	25095.88	29736.61	0.29	8548.56	46407.34	0.29	13341.00
12.00	11663.46	25095.88	36759.34	0.26	9435.21	46407.34	0.26	11911.61
13.00	4640.73	25095.88	29736.61	0.23	6814.86	46407.34	0.23	10635.36
14.00	11663.46	25095.88	36759.34	0.20	7521.69	46407.34	0.20	9495.86
15.00	7243.23	25095.88	32339.11	0.18	5908.23	46407.34	0.18	8478.450
16.00	11663.46	25095.88	36759.34	0.16	5996.24	46407.34	0.16	7570.04
17.00	4640.73	25095.88	29736.61	0.15	4330.97	46407.34	0.15	6758.97
18.00	11663.46	25095.88	36759.34	0.13	4780.17	46407.34	0.13	6034.79
19.00	4640.73	25095.88	29736.61	0.12	3452.62	46407.34	0.12	5388.21
Total	219335.79	476821.66	696157.44		$300397.02	881739.46		$341826.11
NET PRESENT VALUE								$ 41429.10
INTERNAL RATE OF RETURN								25 percent

TABLE 36

COMPUTATION OF NET PRESENT VALUE FOR GREENHOUSE CUCUMBER SPRING/FALL PRODUCTION, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Year	Capital Costs	Operating And Maintenance Costs	Total Costs	Discount Rate 0.12	Present Value 0.12	Total Revenue	Discount Rate 0.12	Present Value 0.12
0.00	51903.13		51903.13	1.00	51903.13		1.00	0.00
1.00	4665.60	28944.27	33609.87	0.89	30008.81	46656.00	0.89	41657.14
2.00	11688.33	28944.27	40632.60	0.80	32392.06	46656.00	0.80	37193.88
3.00	4665.60	28944.27	33609.87	0.71	23922.84	46656.00	0.71	33208.82
4.00	11688.33	28944.27	40632.60	0.64	25822.75	46656.00	0.64	29650.73
5.00	7268.10	28944.27	36212.37	0.57	20547.87	46656.00	0.57	26473.87
6.00	11688.33	28944.27	40632.60	0.51	20585.74	46656.00	0.51	23637.38
7.00	4665.60	28944.27	33609.87	0.45	15203.40	46656.00	0.45	21104.80
8.00	11688.33	28944.27	40632.60	0.40	16410.82	46656.00	0.40	18843.58
9.00	4665.60	28944.27	33609.87	0.36	12120.05	46656.00	0.36	16824.62
10.00	22537.47	28944.27	51481.74	0.32	16575.74	46656.00	0.32	152021.98
11.00	4665.60	28944.27	33609.87	0.29	9662.03	46656.00	0.29	13412.49
12.00	11688.33	28944.27	40632.60	0.26	10429.38	46656.00	0.26	11975.43
13.00	4665.60	28944.27	33609.87	0.23	7702.51	46656.00	0.23	10692.35
14.00	11688.33	28944.27	40632.60	0.20	8314.23	46656.00	0.20	9546.74
15.00	7268.10	28944.27	36212.37	0.18	6615.86	46656.00	0.18	8523.88
16.00	11688.33	28944.27	40632.60	0.16	6628.06	46656.00	0.16	7610.60
17.00	4665.60	28944.27	33609.87	0.15	4895.09	46656.00	0.15	6795.18
18.00	11688.33	28944.27	40632.60	0.13	5283.85	46656.00	0.13	6067.13
19.00	4665.60	28944.27	33609.87	0.12	3902.33	46656.00	0.12	5417.08
Total	219808.24	549941.04	769749.28		$328926.55	886464.00		$343657.69
NET PRESENT VALUE								$ 14731.14
INTERNAL RATE OF RETURN								17 percent

TABLE 37

COMPUTATION OF NET PRESENT VALUE FOR GREENHOUSE TOMATO SPRING/FALL PRODUCTION, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Year	Capital Costs	Operating And Maintenance Costs	Total Costs	Discount Rate 0.12	Present Value 0.12	Total Revenue	Discount Rate 0.12	Present Value 0.12
0.00	51070.93		51070.93	1.00	51070.93		1.00	0.00
1.00	5219.72	26295.88	31515.60	0.89	28138.93	52197.18	0.89	46604.63
2.00	8760.25	26295.88	35056.13	0.80	27946.53	52197.18	0.80	41611.27
3.00	5219.72	26295.88	31515.60	0.71	22432.18	52197.18	0.71	37152.92
4.00	8760.25	26295.88	35056.13	0.64	22278.80	52197.18	0.64	33172.25
5.00	7822.22	26295.88	34118.10	0.57	19359.53	52197.18	0.57	29618.08
6.00	8760.25	26295.88	35056.13	0.51	17760.53	52197.18	0.51	26444.72
7.00	5219.72	26295.88	31515.60	0.45	14256.06	52197.18	0.45	23611.35
8.00	8760.25	26295.88	35056.13	0.40	14158.58	52197.18	0.40	21081.57
9.00	5219.72	26295.88	31515.60	0.36	11364.84	52197.18	0.36	18822.83
10.00	22259.39	26295.88	48555.27	0.32	15633.50	52197.18	0.32	16806.09
11.00	5219.72	26295.88	31515.60	0.29	9059.98	52197.18	0.29	15005.44
12.00	8760.25	26295.88	35056.13	0.26	8998.04	52197.18	0.26	13397.72
13.00	5219.72	26295.88	31515.60	0.23	7222.56	52197.18	0.23	11962.25
14.00	8760.25	26295.88	35056.13	0.20	7173.18	52197.18	0.20	10680.58
15.00	7822.22	26295.88	34118.10	0.18	6233.25	52197.18	0.18	9536.23
16.00	8760.25	26295.88	35056.13	0.16	5718.41	52197.18	0.16	8514.49
17.00	5219.72	26295.88	31515.60	0.15	4590.07	52197.18	0.15	7602.22
18.00	8760.25	26295.88	35056.13	0.13	4558.68	52197.18	0.13	6787.70
19.00	5219.72	26295.88	31515.60	0.12	3659.17	52197.18	0.12	6060.45
Total	200814.48	499621.76	700436.24		$301613.76	991746.42		$384472.78
NET PRESENT VALUE								$ 82859.02
INTERNAL RATE OF RETURN								37 percent

TABLE 38

COMPUTATION OF NET PRESENT VALUE FOR GREENHOUSE CUCUMBER SPRING/FALL PRODUCTION, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Year	Capital Costs	Operating And Maintenance Costs	Total Costs	Discount Rate 0.12	Present Value 0.12	Total Revenue	Discount Rate 0.12	Present Value 0.12
0.00	51070.93		51070.93	1.00	51070.93		1.00	0.00
1.00	5961.60	32535.16	38496.76	0.89	34372.11	59616.00	0.89	53228.57
2.00	9502.13	32535.16	42037.29	0.80	33511.87	59616.00	0.80	47525.51
3.00	5961.60	32535.16	38496.76	0.71	27401.23	59616.00	0.71	42433.49
4.00	9502.13	32535.16	42037.29	0.64	26715.46	59616.00	0.64	37887.05
5.00	8564.10	32535.16	41099.26	0.57	23320.82	59616.00	0.57	33827.72
6.00	9502.13	32535.16	42037.29	0.51	21297.40	59616.00	0.51	30203.32
7.00	5961.60	32535.16	38496.76	0.45	17413.98	59616.00	0.45	26967.25
8.00	9502.13	32535.16	42037.29	0.40	16978.16	59616.00	0.40	24077.90
9.00	5961.60	32535.16	38496.76	0.36	13882.32	59616.00	0.36	21498.13
10.00	23001.27	32535.16	55536.43	0.32	17881.24	59616.00	0.32	19194.76
11.00	5961.60	32535.16	38496.76	0.29	11066.90	59616.00	0.29	17138.18
12.00	9502.13	32535.16	42037.29	0.26	10789.92	59616.00	0.26	15301.94
13.00	5961.60	32535.16	38496.76	0.23	8822.46	59616.00	0.23	13662.45
14.00	9502.13	32535.16	42037.29	0.20	8601.66	59616.00	0.20	12198.61
15.00	8564.10	32535.16	41099.26	0.18	7508.68	59616.00	0.18	10891.62
16.00	9502.13	32535.16	42037.29	0.16	6857.19	59616.00	0.16	9724.66
17.00	5961.60	32535.16	38496.76	0.15	5606.83	59616.00	0.15	8682.73
18.00	9502.13	32535.16	42037.29	0.13	5466.51	59616.00	0.13	7752.44
19.00	5961.60	32535.16	38496.76	0.12	4469.73	59616.00	0.12	6921.82
Total	214910.24	618168.01	833078.25		$353035.41	1132704.00		$439118.15
NET PRESENT VALUE								$ 86082.74
INTERNAL RATE OF RETURN								38 percent

of return for the greenhouse tomato (cucumber) production investment using the bag culture production system. The tables include the total costs and revenues of the greenhouse investment for twenty years. The total costs include the capital costs and the operating and maintenance costs. The total revenues are comprised of the annual crop sales.

The capital costs of the first year represents the initial investment costs of the greenhouse module (Table 39 and 40). For each successive year, the capital costs represents the management charge that is accounted for 10 percent of the annual crop sales. A price of $ 5000 is quoted for the selected land. A better location would be outside the city limits where land prices and property taxes are low. The estimated costs of preparing the land would add $500 to the purchase cost of land. The estimated total cost of land for the greenhouse module is the sum of the purchase price of the land and the cost of preparing the site.

The replacement cost of the external cover and the growing medium are added every two years (Table 41 and 42). The replacement cost of the evaporative cooling pad system and the solenoid valves are added every five years (Table 43). Moreover, the replacement cost of the beds, the watering system, the minor tools and equipment, and the thermostats are added every ten years (Table 44 and 45).

TABLE 39

SUMMARY OF THE TOTAL INVESTMENT, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Activity	Unt	Amt	$Total
Land	acre	0.50	5000.00
Grading & Site preparation	acre	0.50	500.00
Structures	unt	1.00	12296.76
External plastic cover	unt	1.00	1716.75
Heating, Ventilation and cooling systems	sst	1.00	19053.15
Growing Medium	unt	1.00	5266.08
Beds and Watering System	unt	1.00	5274.69
Tools and Equipment	unt	1.00	2795.70
Total	$		51903.13
Total Investment Interest	$		3114.19

Sources:

Dhillion, P. S., and Brumfield, R. G.
Greenhouse tomato production in New Jersey,
Sept 1990

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Greenhouse Structures and Systems. United Greenhouse System. Wisconsin.

TABLE 40

SUMMARY OF THE TOTAL INVESTMENT, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM.

Activity	Unt	Amt	$Total
Land	acre	0.50	5000.00
Grading & Site preparation	acre	0.50	500.00
Structures	unt	1.00	12296.76
External plastic cover	unt	1.00	1716.75
Heating, Ventilation and cooling systems	syst	1.00	19053.15
Growing Medium	unt	1.00	1783.88
Beds and Watering System	unt	1.00	7924.69
Tools and Equipment	unt	1.00	2795.70
Total	$		51070.93
Total Investment Interest	$		3064.26

Sources:

Based on Dhillion, P. S.,and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St. Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Greenhouse Structures and Systems. United Greenhouse System. Wisconsin.

TABLE 41

THE EVERY TWO YEARS REPLACEMENT COSTS, THE BED CULTURE PRODUCTION SYSTEM

Item	Unt	Cost
The external cover	$	1716.75
The growing medium	$	5266.08
Battery	$	39.90
Total	$	$7022.73

TABLE 42

THE EVERY TWO YEARS REPLACEMENT COSTS, THE BAG CULTURE PRODUCTION SYSTEM

Item	Unt	Cost
The external cover	$	1716.75
The growing medium	$	1783.88
Battery	$	39.90
Total	$	3540.53

TABLE 43

THE EVERY FIVE YEARS REPLACEMENT COSTS

Item	Unt	Cost
The evaporating cooling pad system	$	2346.0
1" solenoid valves	$	256.5
Total	$	2602.5

TABLE 44

THE EVERY TEN YEARS REPLACEMENT COSTS,
THE BED CULTURE PRODUCTION SYSTEM

Item	Unt	Cost
Thermostats	$	472.65
Beds	$	3577.68
Watering System	$	1440.51
Minor Tools and Equipments	$	2755.80
Total	$	8246.64

TABLE 45

THE EVERY TEN YEARS REPLACEMENT COSTS, THE BAG CULTURE PRODUCTION SYSTEM

Item	Unt	Cost
Thermostats	$	472.65
Beds	$	3647.68
Watering System	$	4020.51
Minor Tools and Equipments	$	2755.80
Total	$	10896.64

By the time the construction of the greenhouse is completed in the first year, the variable costs of crop production process and the maintenance cost start to build up. The variable and maintenance costs represent the tomato (cucumber) annual cash outflow. These costs are constant for the proposed period of the greenhouse investment.

The annual crop sales represent the sum of the crop sales during the Spring and the Fall seasons. The crop sales are constant for the twenty year investment period. The sum of the difference between the annual costs discounted at 12 percent and the annual revenues discounted at 12 percent gives the net present value of the greenhouse investment.

In Table 35 (36), total costs discounted at 12 percent amount to $300397.02 ($328926.55). Similarly, total revenues discounted at 12 percent amount to $341826.11 ($343657.69). Subtracting the discounted total costs from the discounted total revenues gives a difference of $41429.10 ($14731.14) which is the net present value at a 12 percent discount rate. In other words, the greenhouse tomato (cucumber) production investment will compensate the investor at 12 percent annually and return an additional $41429.10 ($14731.14) in the present value. Moreover, Table 35 (36) shows that the internal rate of return for tomato (cucumber) production venture using the bed culture production system is 25 (17) percent. That means, the maximum interest that the tomato (cucumber) production venture could pay for the resources used is 25 (17) percent if such venture is to recover its initial investment and operating costs and still break even.

In Table 37 (38), total costs discounted at 12 percent are $301613.76 ($353035.41). Similarly, total revenues discounted at 12 percent are $384472.78 ($439118.15). Subtracting the discounted total costs from the discounted total revenues gives a difference of $82859.02 ($86082.74) which is the net present value at 12 percent discount rate. This means that the investment will compensate the investor at 12 percent rate annually and return an additional $82859.02 ($86082.74) in the present value. Moreover, Table 37 (38) shows that the internal rate of return for tomato (cucumber) production venture using the bag culture production system is 37 (38) percent. That means, that the maximum interest that the tomato (cucumber) production venture could pay for the resources used is 37 (38) percent if such venture is to recover its initial investment and operating costs and still break even.

The Risk Analysis

Sensitivity analysis is a straightforward method that is used to analyze the effect of risk and uncertainty in investment analysis. The study changes some of the critical elements that seriously affect the net present value of the greenhouse module. In commercial greenhouse venture in Oklahoma, yield variability due to diseases is the major concern of the growers. One of the diseases seriously affects the greenhouse tomato production in Oklahoma is canker which is hard to eliminate from the greenhouse and causes partial crop failure. Such yield variability increases the riskiness involved in greenhouse vegetable production.

Calculating the net present values of the four production practices using the new estimates of the potential yields and the discount rates show that the net present value of producing tomatoes (cucumbers) using both production systems becomes negative at a 25 percent reduction in the potential yield.

At a 15 percent discount rate, the net present value of tomato (cucumber) production using the bed culture production system declines by about 39 (81) percent. On the other hand, it declines by about 27 (27) percent in the case of the tomato (cucumber) production using the bag culture production system.

At an 18 percent discount rate, the net present value of tomato (cucumber) production using the bed culture production system declines by about 68 (100) percent, and about 48 (47) percent when using the bag culture production system.

At 25 percent, the net present value of tomato (cucumber) production using the bed culture production system turns out negative, and decline by about 80 (79) percent in the case of the bag culture tomato (cucumber) production (Table 46).

TABLE 46

THE RISK ANALYSIS FOR THE INVESTMENT
IN THE GREENHOUSE VEGETABLE PRODUCTION

	Net Present Values ($)			
	Bed Culture		Bag Culture	
States	Tomatoes	Cucumbers	Tomatoes	Cucumbers
12 percent Discount rate	41429.10	14731.14	82859.02	86082.74
15 percent Discount rate	25266.13	2845.09	60155.92	62824.94
18 percent Discount rate	13137.45	-6054.51	43084.52	45336.24
25 percent Discount rate	-5643.87	-19809.16	16595.02	18199.95
25 percent Yield reduction	-35481.78	-62591.84	-3647.35	-12718.84

CHAPTER V

SUMMARY AND CONCLUSION

Many resources are usually involved in the agricultural production process. However, so many challenges have faced the agricultural sector such as water scarcity, soil fertility decline, and weather variability. Actually, these challenges have negatively affected the agricultural production in many countries - if not all. The emergence of these challenges has induced many farmers and researchers to seek practical resolutions to these problems. The efforts of researchers and farmers led to the development of many techniques that could resolve some of these challenges. One of these developed techniques is the use of the greenhouse.

The use of the greenhouse enables growers to achieve three main benefits: (1) get the maximum attainable crop production with the use of scarce resources, (2) control the time of getting a crop produced so that this crop may provide a maximum return to the grower, and (3) allow cultivation in areas with extreme environments or in which cultivation has not been practiced.

However, the use of the greenhouse in crop production is not without problems. One of these is the relatively high initial investment and operating costs which have made the economic use of the greenhouses for vegetable production questionable. Consequently, many studies have been conducted to investigate the economic feasibility of greenhouse vegetable production.

Basically, all studies focus on the economic justification of using greenhouses in different parts of the United States. However, no economic studies had been conducted for the use of greenhouses in Oklahoma. Thus, this study is an attempt to fulfill the following objectives concerning greenhouse vegetable production in Oklahoma: 1) to determine the total investment costs for two common greenhouse growing systems, 2) to estimate costs and returns, and analyze cash flows for two common greenhouse growing systems, and 3) to determine the economic feasibility of greenhouse vegetable production for two common growing systems.

The study focuses on tomato and cucumber production under the two common production systems being used in greenhouses: 1) the bed culture production system, and 2) the bag culture production system, and sheds light on the piping system.

To achieve the proposed goals, the economic analysis is presented through four approaches: 1) the total annual costs and returns budgets, 2) the annual cash flow, 3) a multi-year net present value analysis, and 4) a risk analysis. Each of these four approaches is applied to the following production practices: 1) annual greenhouse tomato production using the bed culture production system, 2) annual greenhouse cucumber production using the bed culture production system, 3) annual greenhouse tomato production using the bag culture production system, and 4) annual greenhouse cucumber production using the bag culture production system.

The greenhouse module chosen for the analysis is a ready made structure that provides 8640 square feet of production area. The 8640 square feet production area consists of three greenhouses, each one encompassing 2880 square feet and covered with a double layer of 6 mil plastic. The essential facilities of each greenhouse are heating, cooling, and ventilation systems. A total of eighteen beds are constructed length-wise in the greenhouse module. An automated feeding system, an automated watering system, and a growing medium are installed in the greenhouse module.

The economic analysis results are:

1- The total annual fixed and variable costs required to produce tomato (cucumber) using the bed culture production system are \$33176.64 (\$37025.03), whereas the total annual revenue is \$46407.34 (\$46656). That gives a grower a net return of \$13230.70 (\$9630.97) per greenhouse module, or \$1.53 (\$1.11) per square feet. On the other hand, the total annual fixed and variable costs required to produce tomato (cucumber) using the bag culture production system are \$33693.89 (\$39960.44), whereas the total annual revenue is \$52197.18 (\$59616.00). That gives a grower a net return of \$18503.29 (\$19655.56) per greenhouse module, or \$2.14

($2.27) per square feet.

2- The annual greenhouse tomato (cucumber) production using the bed culture production system gives an annual cash flow of $21311.46 ($17711.73) per greenhouse module, or $2.47 ($2.05) per square feet. On the other hand, the annual greenhouse tomato (cucumber) production using the bag culture production system gives an annual cash flow of $25901.30 ($27080.84) per greenhouse module, or $3.00 ($3.13) per square feet.

3- In the long run, annual greenhouse tomato (cucumber) production using the bed culture production system compensates the investor 12 percent annually for the assets invested plus an additional discounted profit of $41429.10 ($14731.14) per greenhouse module. On the other hand, the annual greenhouse tomato (cucumber) production using the bag culture production system compensates the investor 12 percent annually on the assets invested plus an additional discounted profit of $82859.02 ($86082.74) per greenhouse module.

4- The above results show that the greenhouse tomato production investment is more profitable than the greenhouse cucumber production investment using the bed culture production system, whereas the greenhouse cucumber production investment is more profitable than the greenhouse tomato production investment using the bag culture production system. Moreover, the bag culture production system is more profitable than the bed culture production system for both crops.

5- The minimum break even price that the greenhouse tomato (cucumber) growers can continue to operate within the short run is \$.75 (\$.76) per pound using the bed culture production system, and \$.68 (\$.64) per pound using the bag culture production system.

6- Due to the existence of disease problems that face greenhouse growers in Oklahoma, there is a high probability of partial crop failure. Hence, the riskiness involved in such investments is high. At a 25 percent reduction of the potential yield, the greenhouse module net present value shows high sensitivity. The net present value for producing tomatoes and cucumbers using both production systems turns out negative.

Increasing the discount rate to reflect the overall yield and price risk also affects the net present value to a great extend. The greater the discount rate applied, the lower the net present value. At a discount rate of 25 percent, the net present value for tomato and cucumber productions using the bed culture production system turns out negative. For tomato and cucumber productions using the bag culture production system, net present values decline 80 and 79 percent, respectively.

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APPENDIX

THE INITIAL INVESTMENT COSTS

TABLE 47

INVESTMENT IN PLASTIC GREENHOUSE/HOUSE, 8640 SQUARE FEET GREENHOUSE MODULE

Item	Unt	Amt	$/unt	$Total
Greenhouse Structure				
Greenhouse Kit 30' x 96' (Ridge and Purlins; Ground Posts and Bows;Fascia board mounted and endbows; Base male/female extrusion for side walls.)	unt	1.00	3036.00	3036.00
Steel Door,36"w x 80"h	unt	1.00	223.88	223.88
Galvanized Wire	coil	2.00	26.90	53.80
Baseboard Lumber, 2"x 10"	ft	252.00	1.07	269.64
Electric Wire, #14	ft	250.00	0.17	42.00
Light Fixtures (4 tubes)	unt	1.00	73.60	73.60
Unskilled labor	hr	48.00	5.00	240.00
Semiskilled	hr	16.00	10.00	160.00
Subtotal	$			4098.92
External Cover				
Polyethylene Film				
Top: roll, 6 mill 40' x 100'	roll	2.00	129.25	258.50
Ends: roll, 6 mill 14' x 100'	roll	2.00	41.15	82.30
Mending Tape	roll	1.00	6.70	6.70
Fascia Tape	roll	1.00	19.35	19.35
Jumper Kits, 24" long	kit	2.00	7.95	15.90
Inflation Kit, Single Stack	kit	1.00	99.50	99.50
Labor	hr	18.00	5.00	90.00
Subtotal	$			572.25
Total Investment/House	$			4671.17
Total Investment	$			14013.51

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Greehouse Structures and Systems. United Greenhouse System. Wisconsin.

TABLE 48

INVESTMENT IN HEATING, COOLING, AND VENTILATING SYSTEMS/HOUSE, 8640 SQUARE FEET GREENHOUSE MODULE

Item	Unt	Amt	$/unt	$Total
Heating, Cooling, and Ventilating Systems/Greenhouse				
Gas - Fired Heaters, 180000 BTU	heater	2.00	1249.00	2498.00
Single Stage Thermostats	unt	3.00	32.00	96.00
Double Leg Heater Hangers	unt	4.00	50.00	200.00
Smoke Stack Pipe Kits	kit	2.00	95.00	190.00
1/2 HP Exhaust Fan With Housing Guard, Fan Size 24", One Speed	fan	1.00	680.00	680.00
1/3 HP Exhaust Fan With Housing Guard, Fan Size 24" With Housing	fan	1.00	660.00	660.00
Aluminum Wall Shutter, Fan size 24"	unt	2.00	105.00	210.00
Two Stage Thermostat	unt	1.00	61.55	61.55
Horizontal Air Flow System	unt	2.00	106.25	212.50
Evaporative Cooling Pad System	unt	2.00	391.00	782.00
Sump Tank With Cover	unt	2.00	75.50	151.00
Plumbing Fitting And Valves Kits	kit	1.00	210.00	210.00
Labor, Electrician	hr	8.00	35.00	280.00
Semiskilled	hr	24.00	5.00	120.00
Total Investment /House	$			6351.05
Total Investment	$			19053.15

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St Louis 1991.

TABLE 49

INVESTMENT IN GROWING MEDIUM, BEDS, AND WATERING SYSTEM, 8640 SQUARE FEET GREENHOUSE MODULE, THE BED CULTURE PRODUCTION SYSTEM

Item	Unt	$/unt	Amt	$Total
Growing Medium for 18 Beds (6 Beds/House)				
Peat Moss	cft	2.23	648.00	1445.04
Vermiculite	cft	1.87	1296.00	2423.52
Perlite	cft	1.74	648.00	1127.52
Labor for Mixing & Filling & Removal	hr	5.00	54.00	270.00
Subtotal	$			5266.08
Cost of 18 Beds				
Lumber 1" x 6"	ft	0.33	6864.00	2265.12
Liner, .006 x 10' x 100' Black Poly	roll	32.92	18.00	592.56
Labor	hr	5.00	144.00	720.00
Subtotal	$			3577.68
Watering System				
1-1/2" Black Polyethylene Main	ft	0.61	90.00	54.90
1" Black Polyethylene Pipe	ft	0.32	1728.00	552.96
1/8" Spray Tube With 24" Feeder Line	ft	0.75	2160.00	162.00
1-1/2" Y Strainer	unt	25.95	3.00	77.85
1" Solenoid Valves	unt	28.50	9.00	256.50
18-Station Irrigation Timer	unt	535.00	1.00	535.00
Miscellaneous-Elbows,Tees, Adapters, Punching Tool,etc.	unt	57.80	1.00	57.80
Subtotal	$			1697.01
Total	$			10540.77

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

TABLE 50

INVESTMENT IN GROWING MEDIUM, BEDS, AND WATERING SYSTEM, 8640 SQUARE FEET GREENHOUSE MODULE, THE BAG CULTURE PRODUCTION SYSTEM

Item	Unt	$/unt	Amt	$Total
Growing Medium				
Peat Moss	cft	2.23	274.00	611.02
Vermiculite	cft	1.87	548.76	1024.76
Potassium Nitrate	lb	0.31	60.00	18.60
Superphosphate	lb	0.19	80.00	15.20
Dolomitic Limestone	lb	0.04	400.00	16.00
Iron Chelate	lb	2.92	2.50	7.30
Boric acid	lb	3.00	2.00	6.00
Labor for Mixing & Filling & removal	hr	5.00	17.00	85.00
Subtotal	$			1783.88
Cost of Beds				
Lumber 1" x 6"	ft	0.33	6864.00	2265.12
Liner, .006 x 10' x 100' Black Poly	roll	32.92	18.00	592.56
Roll white reflective film 36" x 1000'	roll	1.00	70	70
Labor	hr	5.00	144.00	720.00
Subtotal	$			3647.68
Watering System				
1-1/2" Black Polyethylene Main	ft	0.61	90.00	54.90
1" Black Polyethylene Pipe	ft	0.32	1728.00	552.96
1/8" Spray Tube With 24" Feeder Line	ft	0.075	2160.00	162.00
1-1/2" Y Strainer	unt	25.95	3.00	77.85
1" Solenoid Valves	unt	28.50	9.00	256.50
18-Station Irrigation Timer	unt	535.00	1.00	535.00
6 Nutrient Injectors, 0-3 GPM	unt	180.00	6.00	1080.00

TABLE 50 (Continued)

Item/Quantity	Unt	$/unt	Amt	$Total
6 Storage tanks, 900 gl	unt	250.00	6.00	1500.00
Miscellaneous-Elbows,Tees, Adapters, Punching Tool,etc.	unt	57.80	1.00	57.80
Subtotal	$			4277.01
Total	$			9708.57

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

Bauerle, W.L. "Bag Culture Production of Greenhouse Tomato". The Ohio State University. May 1984

TABLE 51

INVESTMENT IN TOOLS AND EQUIPMENT,
8640 SQUARE FEET GREENHOUSE MODULE

Item	Unt	$/unt	Amt	$Total
Polyethylene Sprayer	spr	78.25	1.00	78.25
Pollinator	unt	89.95	2.00	179.90
Battery	unt	19.95	2.00	39.90
Charger	unt	17.95	1.00	17.95
Container, 55 gallon	cnt	20.45	6.00	122.70
Proportioner, 7 gal/m	prt	240.00	6.00	1440.00
Alarm System	unt	239.00	3.00	717.00
Miscellaneous Hand Tools	unt	200.00	1.00	200.00
Total	$			2795.70

Sources:

Dhillion, P. S., and Brumfield, R. G. Greenhouse tomato production in New Jersey, Sept 1990

Horticultural Supplies Catalog, A. H. Hummert Seed Co. St Louis 1991.

Hydo-gardens Ins. Colorado Springs Co. Catalog 90 J.

VITA

Ahmed Mohammed Alabdulkader

Candidate for the Degree of

Master of Science

Thesis: ECONOMIC FEASIBILITY OF GREENHOUSE VEGETABLE PRODUCTION IN OKLAHOMA

Major Field: Agricultural Economics

Biographical:

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