A COST AND RETURN ANALYSIS FOR PRODUCING SAGE AND THYME FOR PROCESSING

By

ANITA MARIE KINSELLA

Bachelor of Science in Agricultural Economics

University of Illinois

Urbana-Champaign, Illinois

1992

Submitted to the Faculty of the
Graduate College of the
Oklahoma State University
in partial fulfillment of
the requirements for
the Degree of
MASTER OF SCIENCE
December, 1993

OKLAHOMA STATE UNIVERSITY

A COST AND RETURN ANALYSIS FOR PRODUCING SAGE AND THYME FOR PROCESSING

Thesis Approved:

Thesis Advisor

Dean of the Graduate College

ACKNOWLEDGEMENTS

I'm not sure there is enough room to thank everyone who helped me reach this point. My sincerest thanks and appreciation to my major advisor, Dr. Joe Schatzer. Without your knowledge, patience, and confidence in my abilities, this page would not be necessary. I would like to thank Dr. Francis Epplin. Your knowledge and sense of humor is much appreciated. I would like to thank Dr. Jim Motes for his help in understanding the materials and methods of the research and allowing me to participate in Bixby activities. And special appreciation to Nancy Maness for cooperating and having fun with me while completing my research.

I would like to extend a special thanks to my undergraduate advisor, Dr. Ray Leuthold from the University of Illinois. Your encouragement and support gave me the opportunity to enter and complete graduate school at Oklahoma State University.

Mom and Dad, I thank you for all the encouragement and support you have given me. To Grandma and Grandpa Klockenbrink, thank you for the letters, phone calls and support. I love you and hope my accomplishments up to this point and beyond will make you proud.

I thank all the friends I have made in the department - both students and faculty. I have received nothing but the sincerest support and help while completing my degree. Especially, Linda and Megan - thank you for being social.

Finally, to Brian Poeppel for your endless encouragement and confidence that I can accomplish anything. From you, I realize what is really important in this life. ☺

TABLE OF CONTENTS

CHAPTER Page

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

Herb and spice companies in the United States import a majority of the commodities they process and sell. In 1992, the United States Department of Agriculture reported the U.S. imported two-thirds of its seasoning needs. In 1991, the U.S. imported $362.3 million and exported $86.6 million of condiments, seasonings, and flavorings. By value, the principal suppliers to the U.S. market were Indonesia, India, and Madagascar.

The U.S. per capita consumption of herbs has increased from approximately one pound in 1965 to over two pounds in 1985 (Kebede, p. 489). Since 1969, imports of sage and thyme have fluctuated but have trended upward (Figures 1 and 2). Food processors are aware that the use of herbs improves the flavor of foods lower in salt, fat, and cholesterol. In addition, the consumption of ethnic foods has also increased. The largest increases have occured for Italian, Mexican, and Chinese food. Most ethnic food is highly seasoned with herbs (Larsen, p. 12). Furthermore, the market for herbs is inelastic (Burns, p. 127). A large increase (decreases) in price will result in a relatively small decrease (increase) in the quantity demanded.

Food processors are interested in more than the dried form of herbs. The extractable essential oils and oleoresins naturally produced by the plants also are

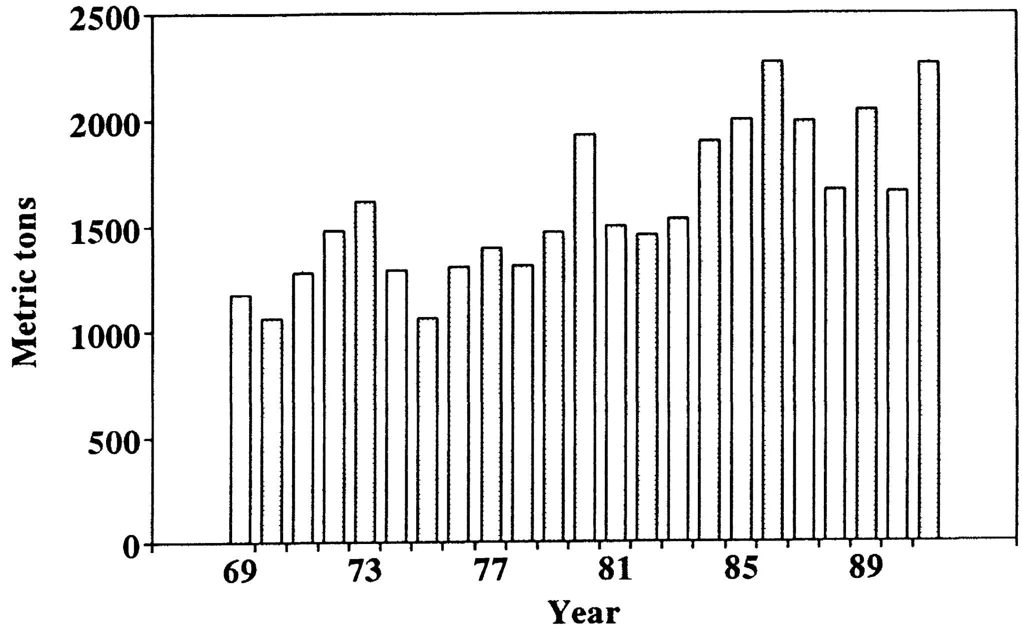

Figure 1. U.S. Imports of Sage

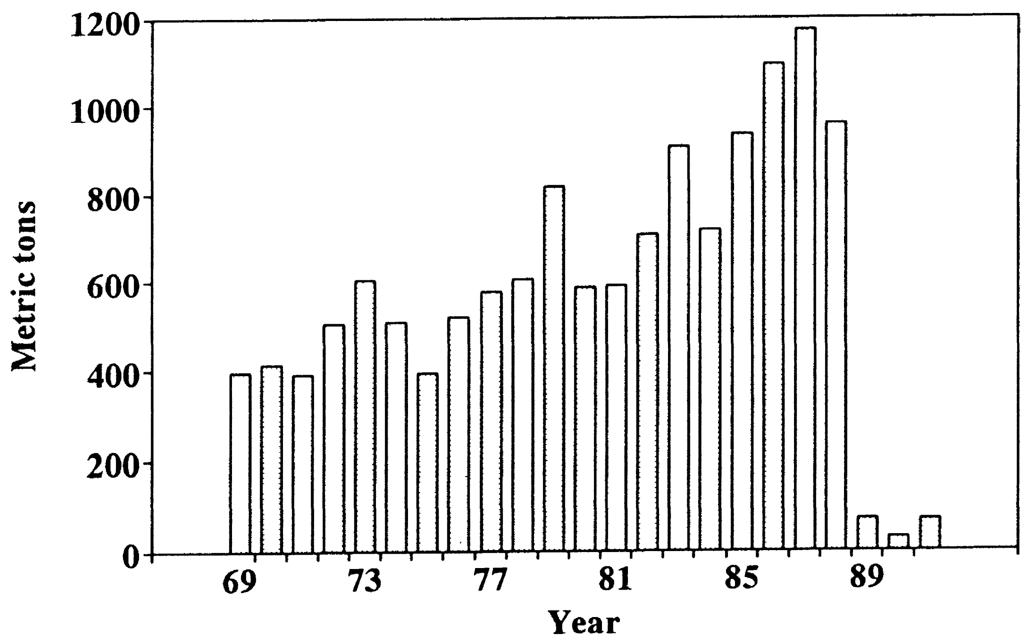

Figure 2. U.S. Imports of Thyme

valuable. An herb's essential oil is a steam volatile oil which a distillation process can remove from the plant material. The essential oil contains the aroma and flavor of the plant material from which it is extracted (Adams, p. 132) The oleoresins are extracted with the use of solvents such as methanol, ethanol, hexane, acetone, or water. The type of solvent used depends upon the desired product and the solubilities of the desirable and undesirable components of the herb (Adams, p. 133). The extracted oleoresin will have the flavor, aroma, and color of the herb. Processers can use the extracts as flavorings in foods and as an additive in pharmaceutical and industrial products (Simon, p. 472). Because of the high concentration, processors must dilute oleoresins before they incorporate the oleoresins into food products. Demand for oleoresins is increasing because the extracts provide consistent quality, freedom from microorganisms, uniform dispersion in the product, and easy handling and storage (United States Department of Agriculture, 1992).

The majority of the essential oils produced in the United States are actually the by-products from citrus, balsam fir, pine, and cedarwood. Peppermint and spearmint are the two major crops grown in the U.S. for their essential oil content. In 1988, the U.S. harvested 32,600 hectares of peppermint with a value of $85.3 million and 9,100 hectares of spearmint with a value of $22.2 million. The United States imported 12,921 MT of essential oils in 1988 with a value of $125.5 million. Specifically, 14 MT of thyme oil was imported with a value of $500,000 in 1988 (Simon p. 472). Sage data was not included.

Sage also naturally produces an antioxidant that is valuable to the food processing industry. An antioxidant will delay spoilage and prolong the life of food products. The natural anitioxidant produced by sage is an alternative to synthetic preservatives widely used by food processors.

Due to the increased demand for spices and herbs, U.S. companies are experiencing problems with the quality differences among imports, government policies of exporting countries that interfere with the flow of trade, and imports tainted with suspected chemicals (Kebede, p. 489). U.S. climatic conditions are suitable for the production of several of these herbs. If U.S. supplies were available, with the same or better quality as the imported supplies, U.S. spice companies would purchase them. To attract farmers, the herbs must provide the farmer with a profit.

Beef cattle is the major commodity in Oklahoma. In 1991, cattle and calves accounted for 54.3% of all cash receipts received from agricultural production. The second largest livestock commodity was poultry which accounted for 6.8% of cash receipts.

Wheat is the other major agricultural commodity in Oklahoma. The Oklahoma Department of Agriculture reported the total value of wheat production was $399 million in 1991. The next largest crop was hay with a value of production of $271.2 million. Wheat planted acreage was 18.3 million hectares in 1991 while hay acreage was 5.93 million hectares. In 1991, wheat accounted for 9.3 percent of cash receipts from agriculutural production in Oklahoma.

Because wheat and beef cattle account for a large portion of Oklahoma agriculture, when one or both of these commodities experience economic downturns, the net farm income for many of the state's farmers is impacted negatively. Since 1980, realized net farm income has displayed large fluctuations (Figure 3). To offset

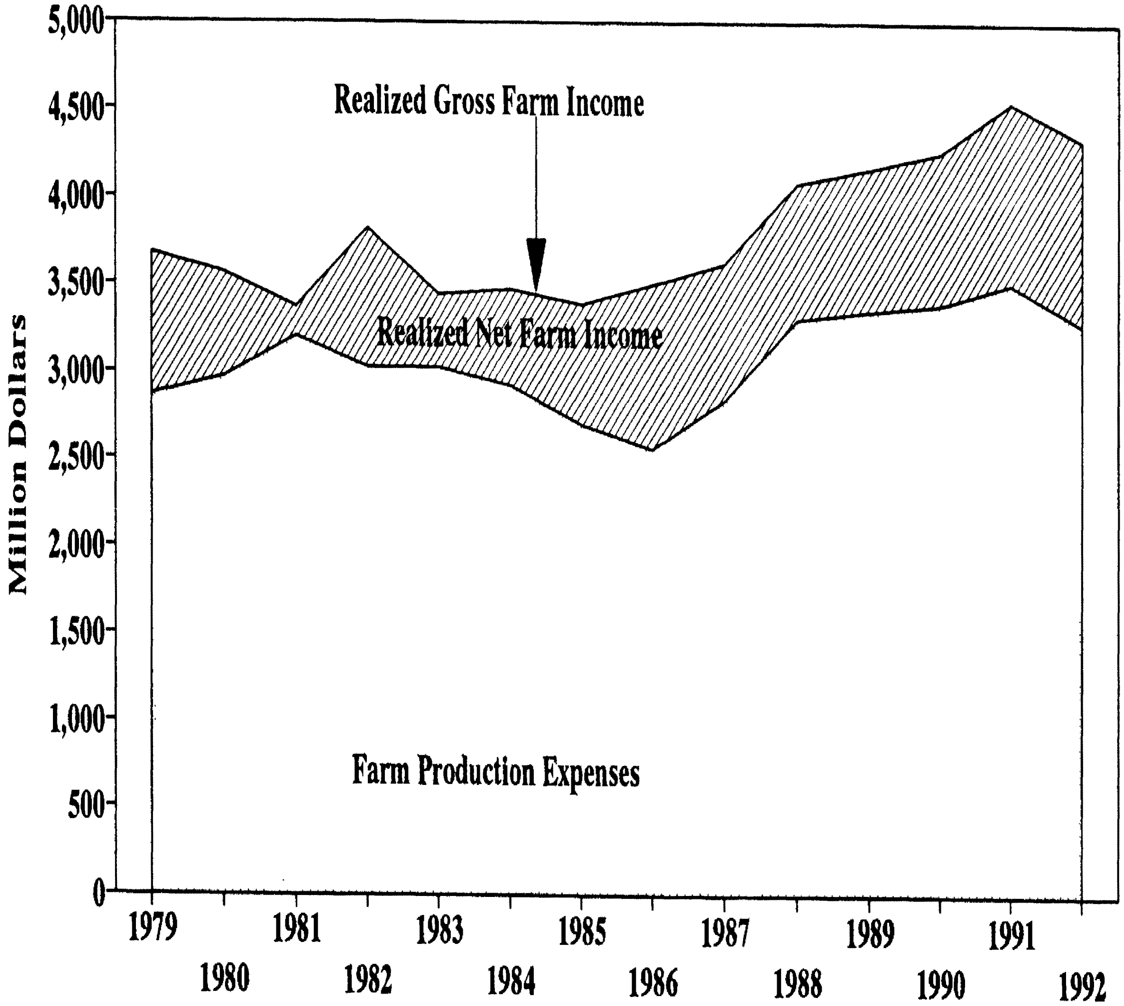

Figure 3. Oklahoma Farm Income, 1979-1992

the impact of fluctuations in income received from wheat and beef cattle, Oklahoma farmers may benefit from diversification. In the past, some farmers have tried alternative crops such as kenaf, fruits, and vegetables.

Oklahoma has the climatic conditions necessary to produce sage and thyme. Horticultural trials show that these herbs may provide an alternative for Oklahoma farmers and satisfy the requirements of U.S. herb and spice companies. However, the cost and return information farmers need to help decide whether to begin production is not presently available. Farmers need to know the cultural practices, capital requirements, levels of inputs, costs, and returns of producing each crop in Oklahoma. Most importantly, the information needs to be reported in a usable fashion so farmers can easily interpret and use the results to make production decisions.

The Department of Horticulture at Oklahoma State University has successfully screened and selected varieties of sage and thyme for certain desirable traits to suit Oklahoma climatic conditions and to allow for mechanical harvesting. Currently, most of the processing herb production in Oklahoma is shipped to the Kalsec, Inc. extraction facility in Kalamazoo, Michigan. Kalsec, Inc. extracts the essential oils and oleoresins from the plants to be used as flavoring for a number of food products and as an antioxidant or food preservative. The remaining question is: Can Oklahoma farmers make a profit producing sage and thyme?

Hypothesis

Oklahoma farmers could improve their welfare and the welfare of U.S. importers by growing herbs to replace imports of sage and thyme. Using data collected from the sage and thyme plot trials, we can determine the most profitable cultural practices for production of sage and thyme. By computing the costs and returns for the optimal cultural practices, we can help farmers determine if producing herbs is more profitable than producing traditional enterprises such as wheat and beef cattle. Our hypothesis is that farmers can produce sage and thyme and increase their profits.

Objectives

Our general objective is to increase the knowledge available to Oklahoma farmers about the economic feasibility of growing sage and thyme. The specific objectives are:

1. Determine the most profitable nitrogen rate and last fall harvest date for growing sage and thyme in Oklahoma.
2. Calculate the expected net returns from the production of sage and thyme.

CHAPTER II

DATA AND PROCEDURES

Data

Two studies of sage and thyme began in 1990 at the Oklahoma State University Vegetable Research Station at Bixby. The two studies examined in-row spacing and nitrogen rate by fall harvest date. Data from 1990-1993 were collected from field experiments conducted at the Bixby research station. We examined the nitrogen rate by fall harvest date data.

The nitrogen by fall harvest date study considered three levels of nitrogen: 60 $kg \cdot ha^{-1}$, 120 $kg \cdot ha^{-1}$, and 180 $kg \cdot ha^{-1}$. All plots received 60 $kg \cdot ha^{-1}$ of nitrogen from urea in April. In mid June, the 120 $kg \cdot ha^{-1}$ and 180 $kg \cdot ha^{-1}$ plots received a second application. At the end of July, the 180 $kg \cdot ha^{-1}$ treatment receives the third and final application for the year. The estimated carryover determined by soil tests for all three levels is 11 $kg \cdot ha^{-1}$ each year.

Sage and thyme are perennials. Therefore, planting costs are not incurred every year. The planting year's costs are amortized over the life of sage and thyme. For the experiment, the life of the crop is four years. With a 10 % interest rate, 40 % of the first year's costs are charged over each of the next three years.

The harvest one year may affect the next year's harvest. The date of the fall harvest may affect the ability of plants to survive the winter and consequentially the yield received in the following year(s). The fall harvest date is also important from the standpoint of cash flow. It may be beneficial to harvest earlier than the maximum yield harvest date to improve cash flow. The four fall harvest dates tested at Bixby were targeted for September 20, October 11, November 1, and November 22. The September and October harvests occur before the dormancy period begins. The plants can regrow before colder temperatures induce dormancy. The early November harvest will not allow regrowth and the late November harvest occurs during winter dormancy. The late November harvest must occur after night temperatures drop to approximately -2°C. Not all fall harvests occured on the exact treatment date due to variable weather conditions. Table 1 lists the actual harvest dates for each harvest period for sage and thyme from 1990 to 1993.

The plots used for the nitrogen by fall harvest date study were established in 1990. In the planting year, the Severn fine sandy loam at Bixby was prepared with a broadcast, preplant application of 51 $kg \cdot ha^{-1}$of N, 22.3 $kg \cdot ha^{-1}$of P, and 42.3 $kg \cdot ha^{-1}$ of K. In 1990, weeds were controlled with a preplant application and September application of oryzalin at 1.12 $kg \cdot ha^{-1}$. Insects were controlled with an application of permethrin at .112 $kg \cdot ha^{-1}$. Thyme also received a September application of methomyl at 1.00 $kg \cdot ha^{-1}$. In 1991, 1992, and 1993, weeds were controlled with two applications of oryzalin at 1.12 $kg \cdot ha^{-1}$ and hand hoeing. Overhead sprinkler irrigation was provided based on soil moisture tests. In 1990, sage was harvested once in September. The thyme plants were too small in 1990 to safely harvest

TABLE 1

HARVEST DATES FOR EACH HARVEST
PERIOD FOR EACH YEAR

Harvest Period	1990	1991	1992	1993
First Sage	September 28	May 13	May 22	May 25
First Thyme		June 17	June 17	May 25
Second Sage		July 9	August 3	August 4
September 20		September 26	September 22	
October 11		October 10	October12	
November 1		November 8	November 2	
November 22		November 22	December 12	

without injury. In 1991, 1992, and 1993, sage was harvested twice prior to the fall harvest date treatment. These harvests are considered regular harvests, and they occured in May and July. Each treatment was harvested a total of three times per year. The thyme was harvested once in June prior to the fall harvest date treatment. Thyme was harvested a total of two times per year.

Weather Factors

Weather can have profound effects on data collected from crops grown in an outdoor environment. On November 3, 1991, a severe freeze occurred at the Oklahoma State University Vegetable Research Station at Bixby. The Oklahoma Climatological Survey reported a low temperature at the Tulsa Airport of -9°C. Prior to November 3, higher temperatures had not allowed the herb plants to acclimate to lower winter temperatures. The plants were not prepared for a hard freeze and the sage plants received some damage. The freeze caused the sage leaves to wilt below a height the harvester could reach. The leaves were present but could not be harvested. The November 22 harvest was not affected by the freeze because the leaves had time to recover. On November 22, the harvester did not have a problem harvesting the leaves. As a result of the freeze, the sage yield for the November 1 harvest was lower than it would have been. The early hard freeze also caused carryover effects for the May 1992 regular harvest of the sage. Thyme was not affected by the November 3 freeze. Thyme is more hardy than sage and can withstand colder temperatures without incurring any damage to the leaves.

Product Prices

Kalsec, Inc. is the primary buyer of Oklahoma grown herbs produced for extraction. The farmers producing sage and thyme rely on Kalsec's support to sell their product. Currently, the price the farmer receives depends on the contract between Kalsec and the farmer. We assume the price of sage and thyme is \$882 Mg^{-1} on a dry weight basis. The price per megagram is the price the farmer receives with the product loaded on the shipping vehicle.

Procedures

Fall Harvest Date by Nitrogen Yield Estimation

We used ordinary least squares regression to estimate equations for each crop to decide if any significant yield differences occur among fall dates of harvest or nitrogen rates. The initial model specification is

$$Y=\alpha+\beta_1 N+\beta_2 N^2+\beta_3 H2+\beta_4 H3+\beta_5 H4$$

where Y = dry weight yield in kilograms per hectare for each harvest ($kg \cdot ha^{-1}$);

α = intercept;

N = kilograms of nitrogen applied per hectare;

N^2 = kilograms of nitrogen applied per hectare squared;

H2 = dummy variable for the November 1 harvest;

H3 = dummy variable for the October 11 harvest;

H4 = dummy variable for the September 20 harvest.

The dummy variable for the November 22 harvest was excluded from the equation. With this specification, the intercept represents the November 22 harvest with no application of nitrogen and the three dummy variables represent the change in yield from the November 22 harvest. We tested the goodness of fit for each estimation by the R-square. The R-square is reported as the percent variation in the dependent variable explained by the independent variable(s). We used the F-test and the t-test to test the significance of the independent variables. The null hypothesis for the F-test is $\beta_1=0$, $\beta_2=0$,... $\beta_n=0$ and we used a five percent level of significance. If the null hypothesis is accepted, the coefficients are equal to zero and there is no relationship between the yield and the different nitrogen rates or fall harvest date. If the null hypothesis is rejected in favor of the alternative hypothesis, a relationship exists. We tested the significance of the individual independent variables using the standard two-tailed t-test with a five percent level of significance. The null hypothesis for the two-tailed test is $\beta_i=0$. The alternative hypothesis is $\beta_i\neq0$. If the null hypothesis is accepted, the coefficient is not significantly different from zero. If the null hypothesis is rejected, the coefficient is significantly different from zero. The β_i coefficient for a significant variable estimates the impact the variable has on the dependent variable. We dropped insignificant variables and rerun the regressions.

Seven critical assumptions must be met to perform hypotheses tests from results of ordinary least squares regression. The assumptions and implications are:

1. For each set of observations, the mean value of the error term is zero. The regression estimate for the intercept is adversely affected if this assumption is invalid.

2. For each set of observations, the error or disturbance term has a constant variance for all observations. Disturbances are homoskedastic

when this assumption is valid; heteroskedastic when it is not. Regression parameter estimates do not have least variance when this assumption is invalid.

3. For any two sets of observations, the error or disturbance terms are uncorrelated. Regression parameter estimates do not have least variance when this assumption is invalid.

4. Each independent variable is uncorrelated with the disturbance term. The averages of the regression parameter estimates over many samples are biased when this assumption is invalid.

5. No exact linear relationships exist among the independent variables.

6. The number of observations must exceed the number of explanatory variables, including the intercept.

7. In repeated sampling of the dependent variable and the disturbance term for a given set of the independent variables, the disturbance has a normal distribution. This assumption is necessary if tests of hypothesis based on t and F distributions are conducted (Ray p. 17).

We anticipated heteroskedasticity because it is a common problem with cross-sectional data sets. The presence of heteroskedasticity produces unbiased but inefficient regression estimates. To test for homoskedastic results, we used the Glejser test. The null hypothesis is that homogeneity exists. To calculate the test statistic, we regress the absolute value of the error term on the independent variables. The test statistic has a chi-square distribution with k-1 degrees of freedom where k is the number of independent variables including the intercept if one is included. We use a five percent level of significance. If the calculated test statistic is less than the tabled chi-squared value, the null hypothesis is accepted and the disturbances are homoskedastic. If the calculated test statistic exceeds the tabled chi-squared value, the null hypothesis is rejected and heteroskedasticity is present. A data transformation of the dependent variable is the simplest but not always successful way to correct for heteroskedasticity. Taking the natural log, square root, or square of the dependent variable may improve the results if heteroskedasticity is present. If a data transformation does not produce homoskedastic results, a generalized least squares procedure may correct the problem.

Cost and Return Estimates

We can use the regression results to estimate yield for the regular harvest date(s), fall harvest dates, and three levels of nitrogen. Preliminary cost and return estimates for sage and thyme were developed by Dr. Joe Schatzer and Dr. Jim Motes. The cost and return estimates list variable costs, fixed costs, and production estimates. The returns above total operating costs and returns above total costs except overhead, risk, and management are calculated. We can use the cost and return estimates to compare the net returns among alternative production methods. By comparing, we can determine which combination of last fall harvest date and nitrogen level maximizes returns to the farmer.

CHAPTER III

YIELD ANALYSIS AND ESTIMATION

Yield Calculations

The data collected by the Department of Horticulture were used to compute the dry weight basis yield in kilograms per hectare for the sage and thyme nitrogen by fall harvest date study. The kilograms per hectare dry weight yield is computed based on the harvested wet weight and a sample percent dry weight. Percent dry weight (PDW) was calculated based on a single sample from each experimental unit. We tested the significance between the PDW figures of all harvests (regular and fall harvest) and the fall harvest date using ordinary least squares regression. The model specification for the PDW equations is

$$Y=\alpha+\beta_1 H2+\beta_2 H3+\beta_3 H4$$

where Y = percent dry weight;

α = intercept;

H2 = dummy variable for the November 1 fall harvest date;

H3 = dummy variable for the October 11 fall harvest date;

H4 = dummy variable for the September 20 fall harvest date.

The equations are estimated for sage and thyme for each regular harvest and last fall harvest date for 1991 to 1993. Each equation has 36 observations — four last fall dates by three nitrogen levels with three repetitions for each combination. We expected a low R-squared value and insignificant coefficients for the regular harvest equations. The amount of time available for normal water reduction due to cold temperature acclimation varies among the fall harvest dates. Therefore, we expected the PDW figures to be correlated with the fall harvest date treatments. The results of the regression estimations are listed in Table 2 for sage and in Table 3 for thyme.

Sage Percent Dry Weight

The regular harvest PDW figures are similar because they are harvested at approximately the same time each year. The PDW for the fall harvest treatments vary because the later harvest date treatments provide the crop more time to reduce the water content for cold temperature acclimation. Results for the PDW regressions for May 1991 and July 1991 revealed no significant difference among the PDW figures across the harvest date treatments. We used the average PDW across all treatments to calculate the kilograms per hectare dry weight yield. We expected the PDW to vary among the fall harvest date treatments. The estimation for the fall 1991 PDW produces a high R-square and significant t-statistics for the independent variables. We calculated the yield for the 1991 fall harvest using the average PDW for each fall harvest date treatment. The estimation for May 1992 revealed a significant difference among the PDW figures. The variation could be carryover effects of the November 3, 1991 freeze. We calculated the May 1992 yields using

TABLE 2

STATISTICAL RESULTS FOR REGRESSIONS OF SAGE PERCENTAGE DRY WEIGHT ON FALL HARVEST DATE DUMMY VARIABLES[a]

Item	Harvest Date							
	MAY 1991	JULY 1991	FALL 1991	MAY 1992	AUG 1992	FALL 1992	MAY 1993	AUG 1993
R-SQUARE	.021	.120	.949	.331	.133	.890	.349	.157
F-VALUE	.223	1.455	199	5.27	1.63	85.9	5.71	1.99
INTERCEPT	.198 (.263)*	.344 (.581)*	.415 (.476)*	.210 (.008)*	.268 (.509)*	.393 (.617)*	.221 (.392)*	.320 (.661)*
Nov. 1	-.001 (.372)	-.017 (.822)*	-.089 (.673)*	.019 (1.14)	.004 (.720)	-.046 (.872)*	.001 (.554)	.012 (.935)
Oct. 11	-.003 (.372)	-.011 (.822)	-.117 (.673)*	.025 (1.14)*	.014 (.720)	-.081 (.872)*	.019 (.554)*	.005 (.935)
Sept. 20	-.002 (.372)	-.008 (.822)	-.159 (.673)*	.045 (1.14)*	.012 (.720)	-.135 (.872)*	.013 (.554)*	.021 (.935)*

[a] Standard errors are in parentheses and are multiplied by 10^2.
* Standard errors significant at $P \leq 0.05$.

TABLE 3

STATISTICAL RESULTS FOR REGRESSIONS OF THYME PERCENTAGE DRY WEIGHT ON FALL HARVEST DATE DUMMY VARIABLES[a]

Item	Harvest Date			
	FALL 1991	JUNE 1992	FALL 1992	MAY 1993
R-SQUARE	.832	.286	.748	.351
F-VALUE	52.3	4.27	31.7	5.76
INTERCEPT	.372 (.491)*	.313 (1.13)*	.440 (.893)*	.321 (.916)*
Nov. 1	-.037 (.694)*	-.034 (1.60)	-.042 (1.26)*	.031 (1.30)*
Oct. 11	-.050 (.694)*	.022 (1.60)	-.072 (1.26)*	-.003 (1.30)
Sept. 20	-.087 (.694)*	.004 (1.60)	-.119 (1.26)*	-.022 (1.30)

[a] Standard errors are in parentheses. Standard errors are multiplied by 10^2.
* Standard errors significant at $P \leq 0.05$.

the average PDW for each fall harvest date treatment. The August 1992 PDW estimation shows little variation among the PDW figures across the fall harvest date treatments. We used the average PDW to calculate the yields. The 1992 fall harvest estimation has a high R-square and significant t-statistics. We calculated the yields using the average PDW for each fall harvest date treatment. The May 1993 regular harvest also uses the average PDW for each fall harvest date because there is a significant difference among the PDW figures. The August 1993 estimation indicates no significant difference among the PDW figures. Table 4 lists the PDW figures we used to calculate the dry weight yield for sage.

Thyme Percent Dry Weight

Data are not available for the thyme June 1991 percent dry weight. The June 1992 PDW estimation does not indicate any significant difference among the PDW figures. We used the mean PDW across all treatments for the June 1992 yield calculations. We assumed this PDW to be an accurate mean PDW figure for June 1991. The fall 1991 PDW estimation has a high R-square and significant t-values for the independent variables. We used the average PDW for each fall harvest date treatment to calculate the dry weight yield for each fall harvest date. Similar results occur for the fall 1992 PDW regression equation. We calculated the dry weight yields for the fall harvests using the average PDW for each fall harvest date. We calculated the May 1993 harvest dry weight yields using the average across all treatments. Table 4 also lists the PDW figures we used to calculate the dry weight yield for thyme.

TABLE 4

PERCENTAGE DRY WEIGHT USED TO CALCULATE THE DRY WEIGHT YIELD OF SAGE AND THYME

	Harvest Treatment				
Harvest Period	All	Nov. 22	Nov. 1	Oct. 11	Sept. 20
			Sage		
MAY 1991	.197				
JULY 1991	.333				
FALL 1991		.415	.326	.298	.257
MAY 1992		.210	.230	.236	.255
AUGUST 1992	.275				
FALL 1992		.393	.347	.312	.257
MAY 1993		.221	.222	.240	.235
AUGUST 1993	.330				
			Thyme		
JUNE 1991	.311				
FALL 1991		.372	.398	.322	.286
JUNE 1992	.311				
FALL 1992		.440	.398	.368	.320
MAY 1993		.321	.352	.318	.299

Interpretation of Yield Equations

We used the data for the sage and thyme regular and fall harvests to estimate equations for each harvest date using ordinary least squares regression. For 1991, the regular harvests are expected to have no significant relationship with the fall harvest date treatments. Nitrogen rate is the only factor which changes across the trial plots. After the regular harvests for 1991, we expect any significant differences among the trail plot dry weight yields to be a function of the nitrogen level and the fall harvest date.

We estimated an equation for each regular and fall harvest for sage and thyme. Each equation has a total of 36 observations — four fall harvest dates by three nitrogen level with three repetitions for each combination. The yield equations included in the interpretation are for harvest date yields which exhibited significant differences for the fall harvest date treatment, the nitrogen treatment, or both. The estimated equations are presented in Tables 5 and 6.

The Glejser test is used to test for the presence of heteroskedasticity for the sage and thyme estimations. The chi-squared values are reported in Tables 5 and 6. We used a five percent level of significance to determine if homogeneity exists. The null hypothesis is accepted for all equations. We concluded that heteroskedasticity was not present in the reported regression equations.

TABLE 5

PARAMETER ESTIMATES AND SELECTED STATISTICS
FOR ORDINARY LEAST SQUARE REGRESSIONS
FOR SAGE YIELD[a]

	FALL 1991	MAY 1992	AUG 1992	FALL 1992	MAY 1993	AUG 1993
Intercept	3320 (292)	3782 (127)	-1158 (508)	7.7379 (.0863)	2533 (163)	
Nitrogen (kg • ha^{-1})	3.80 (2.20)					
Nitrogen (kg • ha^{-1})^2				.000011586 (.00000363)		
Nov. 1 harvest dummy	-797 (249)				-561 (231)	427 (190)
Oct. 11 harvest dummy		-1735 (221)	456 (194)	-.325 (.106)	-550 (231)	-339 (191)
Sept. 20 harvest dummy		-2911 (221)		-.972 (.106)	-1044 (231)	
Yield Fall 1991			.554 (.116)			
Yield May 1992			.6780 (.0655)			
Yield May 1993						1.574 (.0520)
R-square	0.29	.850	.776	.750	.390	.793
F-value	6.60	93.6	37.0	23.2	6.82	
Glejser test X^2	.865	3.26	2.56	.387	1.65	-6.434

[a] Dependent variables are sage yield in kg • ha^{-1} except fall 1992 is ln (kg • ha^{-1}). Standard errors are in parentheses. All coefficients significant at $P \leq 0.05$ except Nitrogen for Fall 1991 significant at $P \leq 0.10$.

TABLE 6

PARAMETER ESTIMATES AND SELECTED STATISTICS
FOR ORDINARY LEAST SQUARE REGRESSIONS
FOR THYME YIELD[a]

	FALL 1992	MAY 1993
Intercept	62.6 (4.32)	1547 (89.2)
Nitrogen ($kg \cdot ha^{-1}$)	.0647 (.0279)	
Nov. 1 harvest dummy	-10.72 (3.86)	421 (155)
Oct. 11 harvest dummy	-21.04 (3.86)	643 (155)
Sept. 20 harvest dummy	-17.46 (3.86)	
R-square	.563	.369
F-value	9.96	9.66
Glejser test X^2	2.51	.741

[a] Dependent variables are thyme yield in $kg \cdot ha^{-1}$ except fall 1992 is $(kg \cdot ha^{-1})^{-2}$. Standard errors are in parentheses and are significant at $P \leq 0.05$.

Sage Fall 1991

The estimation for fall 1991 has an R-square of .29. The November 1 dummy variable is significant at the five percent level of significance and nitrogen is significant at the ten percent level of significance. The calculated F-statistic is equal to 6.60 which is significant at the five percent level of significance. The November 22 harvest is equal to the value of the constant plus the increase due to nitrogen. The nitrogen level is assumed to be 180 $kg \cdot ha^{-1}$. Nitrogen is expected to increase the dry weight yield 3.80 $kg \cdot ha^{-1}$ for each additional unit applied. The coefficient for November 1 equals -797 $kg \cdot ha^{-1}$. The November 1 harvest occured after the November 3, 1991 freeze. The freeze damaged the sage plants and reduced the dry weight yield for November 1. The October 11 and September 26 harvests are not significantly different from the November 22 harvest.

Sage May 1992

The estimation for the May 1992 harvest has an R-square of .85. The intercept, October 11, and September 20 dummy variables are significant at the five percent significance level. The calculated F-statistic is equal to 93.6 and is significant at the five percent significance level. The yield for May 1992 harvest with the November 22 treatment is equal to the intercept. The yield for May 1992 with the October 11 treatment is 1,735 $kg \cdot ha^{-1}$ less than the November 22 treatment. The yield for the September 20 treatment is 2,911 $kg \cdot ha^{-1}$ less than the November 22 treatment. The November 1 treatment is not significantly different from the November 22 treatment.

Sage August 1992

The estimation for the August 1992 harvest has an R-square equal to .776. The intercept, May 1992, fall 1991, and the October 11 dummy variable are significant at the five percent level. The dependent variable is a function of two harvest periods — May 1992 and fall 1991. The estimated yield for the August 1992 harvest with the November 22 treatment is equal to 67.8 percent of the May 1992 yield plus 55.4 percent of the fall 1991 yield minus 1,158. The estimated yield with the October 11 treatement is 456 $kg \cdot ha^{-1}$ greater than the November 22 treatment if the May 1992 and fall 1991 yield is the same for both treatments.

Sage Fall 1992

The fall 1992 estimation has an R-square equal to .750. The independent variables nitrogen squared, October 11 dummy variable, September 20 dummy variable, and the intercept are significant at the five percent level. The independent variable, fall 1992 yield, is transformed by taking the natural log of the variable. After testing various transformations for the independent variable, the natural log of the independent variable produced the best fit for the equation without heteroskedasticity. Nitrogen squared has a positive coefficient and is expected to increase the the dry weight yield. The average increase in the fall 1992 yield across the four fall harvest dates when nitrogen is increased from 60 $kg \cdot ha^{-1}$ to 120 $kg \cdot ha^{-1}$ is 402 $kg \cdot ha^{-1}$. The average increase in fall 1992 yield across the fall harvest dates when nitrogen is increased from 120 $kg \cdot ha^{-1}$ to 180 $kg \cdot ha^{-1}$ is 332 $kg \cdot ha^{-1}$. The coefficient for October 11 is equal to -.325. The yield for the October 11 harvest with 180 kg $\cdot$ ha^{-1} is calculated as $e^{\{7.7379 + (.000011586 \times 180 \times 180) - .325\}}$. The value equals 2,411 kg $\cdot$ ha^{-1}. The yield for the September 20 harvest with 180 kg $\cdot$ ha^{-1} is calculated as $e^{\{7.7379 + (.000011586 \times 180 \times 180) - .972\}}$. The value is equal to 1,263 kg $\cdot$ ha^{-1}. The November 1 harvest is not significantly different from the November 22 harvest.

Sage May 1993

The estimation for the May 1993 harvest date has an R-square value of .390. The intercept, November 1, October 11, and September 20 dummy variables are significant at the five percent level. The yield for May 1993 with the November 22 treatment is equal to the intercept coefficient. The yield for May 1993 with the November 1 treatment is 561 kg $\cdot$ ha^{-1} less than the November 22 treatment. The yield with the October 11 treatment is 550 kg $\cdot$ ha^{-1} less than the November 22 treatment. The yield with the September 20 treatment is 1,044 kg $\cdot$ ha^{-1} less than the November 22 treatment.

Sage August 1993

The R-square value for the August 1993 harvest is equal to .793. The intercept, May 1993, November 1 dummy variable, and the October 11 dummy variable are significant at the five percent level. The dependent variable is a function of the May 1993 harvest. The estimated yield for August 1993 harvest with the November 22 treatment is equal to 157.4 percent of the May 1993 yield. The yield for August 1993 with the November 1 treatment is 427 kg $\cdot$ ha^{-1} greater than the November 22 treatment if the May 1993 yield is the same for both treatments. The yield with the October 11 treatment is 339 kg$\cdot$ha^{-1} less than the November 22 treatment if the May 1993 yield is the same for both treatments. The yield with the November 1 treatment is not significantly different from the November 22 treatment if the May 1992 yield is the same for both treatments.

Thyme Fall 1992

The estimation for Fall 1992 has an R-square of .563. The intercept, nitrogen, November 1, October 11, and September 20 dummy variables are significant at the five percent level. The dependent variable is transformed by taking the square root of the variable. After testing various transformations of the independent variable, the square root of fall 1992 yield gave the best fit. Nitrogen has a negative coefficient and is expected to lower the fall yield as the level of nitrogen increases. The November 22 harvest with 180 kg$\cdot$ha^{-1} is equal to $\{62.6 + (.0647 \times 180)\}^2$. The value is equal to 5,520 kg$\cdot$ha^{-1}. The November 1 harvest with 180 kg$\cdot$ha^{-1} is equal to $\{62.6 + (.0647 \times 180) - 10.72\}^2$. The value is equal to 4,042 kg$\cdot$ha^{-1}. The October 11 harvest with 180 kg$\cdot$ha^{-1} is equal to $\{62.6 + (.0647 \times 180) - 21.04\}^2$. The value is equal to 2,837 kg$\cdot$ha^{-1}. The September 20 harvest with 180 kg$\cdot$ha^{-1} is equal to $\{62.6 + (.0647 \times 180) - 17.46\}^2$. The value is equal to 3,230 kg$\cdot$ha^{-1}.

Thyme May 1993

The May 1993 harvest has an R-square equal to .369. The intercept, November 1 dummy variable, and the October 11 dummy variable are significant at the five percent level. The yield for the May 1993 harvest with the November 22 treatment is equal to the intercept coefficient. The yield for the May 1993 harvest with the November 1 treatment is 421 kg•ha^{-1} greater than the November 22 treatment. The yield with the October 11 treatment is 643 kg•ha^{-1} greater than the November 22 treatment. The November 1 treatment is not significantly different from the November 22 treatment.

Dry Weight Yield Estimations

The estimations of the dry weight yield for sage and thyme are calculated based on the regression equations in Tables 5 and 6. Tables 7 and 8 list the estimated yields in kg•ha^{-1}. Nitrogen is not a significant variable for all harvests. In the yield tables, NA replaces the nitrogen level for the harvest dates which do not have a nitrogen response. If nitrogen level is a significant variable and has a positive coefficient, it is assumed to have a linear effect on yield. A linear effect increases the dry weight yield with increasing levels of nitrogen. The maximum level of nitrogen, 180 kg•ha^{-1}, is the maximum nitrogen level used to compute the dry weight yield if nitrogen is a significant variable for the harvest.

TABLE 7

SAGE YIELDS CALCULATED FROM THE ORDINARY LEAST SQUARE REGRESSION EQUATIONS

Nitrogen	Nov. 22	Nov. 1	Oct. 11	Sept. 20
	$kg \cdot ha^{-1}$	$kg \cdot ha^{-1}$	$kg \cdot ha^{-1}$	$kg \cdot ha^{-1}$
		Planting Year 1990		
NA	2,270	2,270	2,270	2,270
		May 1991		
NA	3,070	3,070	3,070	3,070
		July 1991		
NA	3,410	3,410	3,410	3,410
		Fall 1991		
60	3,548	2,751	3,548	3,548
120	3,776	2,979	3,776	3,776
180	4,004	3,207	4,004	4,004
		May 1992		
NA	3,782	3,782	2,047	871
		August 1992		
60	3,372	2,930	2,904	1,398
120	3,498	3,057	2,778	1,524
180	3,624	3,183	2,904	1,650
		Fall 1992		
60	2,391	2,391	1,727	905
120	2,710	2,710	1,957	1,025
180	3,339	3,339	2,411	1,263
		May 1993		
NA	2,533	1,972	1,983	1,489
		August 1993		
NA	3,990	3,530	2,782	2,346

TABLE 7 (Continued)

Nitrogen	Nov. 22	Nov. 1	Oct. 11	Sept. 20
	$kg \cdot ha^{-1}$	$kg \cdot ha^{-1}$	$kg \cdot ha^{-1}$	$kg \cdot ha^{-1}$
		Fall 1993		
60	2,830	2,880	1,812	1,519
120	3,091	3,129	1,960	1,578
180	3,676	3,702	2,310	1,796

TABLE 8

THYME YIELDS CALCULATED FROM THE ORDINARY LEAST SQUARE REGRESSION EQUATIONS

Nitrogen	Nov. 22	Nov. 1	Oct. 11	Sept. 20
kg • ha^{-1}	kg • ha^{-1}	kg • ha^{-1}	kg • ha^{-1}	kg • ha^{-1}
		June 1991		
NA	2,660	2,660	2,660	2,660
		Fall 1991		
NA	2,432	2,432	2,432	2,432
		June 1992		
NA	3,238	3,238	3,238	3,238
		Fall 1992		
60	4,426	3,115	2,070	2,408
120	4,958	3,563	2,438	2,804
180	5,520	4,042	2,837	3,230
		May 1993		
NA	1,547	1,968	2,190	1,547
		Fall 1993		
60	2,115	1,893	1,399	1,150
120	2,369	2,165	1,649	1,340
180	2,637	2,456	1,918	1,543

CHAPTER IV

COST AND RETURN ESTIMATES

The dry weight yields estimated by the regression equations for sage and thyme are used to calculate cost and return figures on a per hectare basis. The dry weight yields for sage and thyme are computed for each fall harvest date treatment for each level of nitrogen. If a harvest period did not have an estimated equation, we assumed the mean dry weight yield for the harvest period to be the yield for each fall harvest date at each level of nitrogen. Data is not available for the 1993 dry weight yields for the fall harvest date treatments. The 1993 fall dry weight yields for sage and thyme are assumed to be a function of previous harvest dates. Sage 1993 fall harvest yields are calculated as (Fall 1992 Yield)×(August 1993 Yield)÷(August 1992 Yield). Thyme 1993 fall harvest yields are calculated as (Fall 1992 Yield) ×(May 1993 Yield)÷(June 1992 Yield). The calculated dry weight yields for sage were reported in Table 7 and for thyme were reported in Table 8. The estimated yields are used to figure the returns above total operating costs and returns above all costs except overhead, risk, and management using the OSU Enterprise Budget Generator. Copies of the enterprise budgets for sage and thyme for each year for the November 22 fall harvest date for each year are included in the appendix.

Tables 9 and 10 present the sage returns for each fall harvest date at each level of nitrogen. Table 9 lists the sage returns above operating costs by year by last harvest date. The optimal combination of nitrogen and fall harvest date treatment is November 22 with 180 kg•ha^{-1} nitrogen. The total return above operating costs for 1990 to 1993 for the November 22 treatment with 180 kg•ha^{-1} is $16,276.46. The total return above all costs except overhead, risk, and management for the four years for the November 22 treatement with 180 kg•ha^{-1} nitrogen is equal to $13,187.30.

Tables 11 and 12 include the thyme returns for each fall harvest date for each level of nitrogen. Thyme has the same response as sage. The greatest return above total operating costs and return above all costs except overhead, risk, and management are found for the November 22 treatment with 180 kg•ha^{-1} of nitrogen applied. The total return above operating costs for 1990 to 1993 for the November 22 treatment with 180 kg•ha^{-1} is $3,449.79. The total return above all costs except overhead, risk, and management for the four years for the November 22 treatment with 180 kg•ha^{-1} is equal to $1,642.28.

TABLE 9

SAGE RETURNS ABOVE OPERATING COSTS
BY YEAR BY FALL HARVEST DATE

YEAR	Nov. 22	Nov. 1	Oct. 11	Sept. 20
	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$
		Nitrogen=60		
1990	(486.11)	(486.11)	(486.11)	(486.11)
1991	5,092.35	4,605.70	5,099.72	5,107.08
1992	4,783.22	4,506.84	2,871.39	867.99
1993	4,680.33	4,082.76	2,968.28	2,063.25
Total	14,069.79	12,709.19	10,453.28	7,552.21
		Nitrogen=120		
1990	(510.76)	(510.76)	(510.76)	(510.76)
1991	5,197.90	4,708.80	5,189.43	5,212.74
1992	5,024.06	4,747.46	3,050.40	979.00
1993	4,800.17	4,196.47	3,020.39	2,220.08
Total	14,511.37	13,141.97	10,749.46	7,901.06
		Nitrogen=180		
1990	(540.83)	(540.83)	(540.83)	(540.83)
1991	5,530.45	4,806.90	5,294.76	5,295.96
1992	5,447.28	5,170.91	3,369.13	1,162.44
1993	4,757.90	4,505.83	3,193.72	2,313.33
Total	16,276.46	13,942.81	11,316.78	8,230.90

TABLE 10

SAGE RETURNS ABOVE ALL COSTS EXCEPT
OVERHEAD, RISK, AND MANAGEMENT

YEAR	Nov. 22	Nov. 1	Oct. 11	Sept. 20
	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$
		Nitrogen=60		
1990	(1,020.42)	(1,020.42)	(1,020.42)	(1,020.42)
1991	4,670.44	4,183.79	4,677.81	4,685.17
1992	4,361.31	4,084.93	2,449.48	446.08
1993	4,258.43	3,660.85	2,546.37	1,641.34
Total	12,269.76	10,909.15	8,653.24	5,752.17
		Nitrogen=120		
1990	(1,046.00)	(1,046.00)	(1,046.00)	(1,046.00)
1991	4,774.16	4,286.89	4,766.58	4,789.89
1992	4,601.22	4,324.61	2,627.56	556.16
1993	4,377.32	3,773.62	2,597.54	1,797.24
Total	12,706.70	11,339.12	8,945.68	6,097.29
		Nitrogen=180		
1990	(1,077.01)	(1,077.01)	(1,077.01)	(1,077.01)
1991	4,906.68	4,383.13	4,870.98	4,872.19
1992	5,023.51	4,747.13	2,945.35	738.66
1993	4,334.12	4,081.55	2,769.95	1,889.56
Total	13,187.30	12,134.80	9,509.27	6,423.40

TABLE 11

THYME RETURNS ABOVE OPERATING COSTS
BY YEAR BY FALL HARVEST DATE

YEAR	Nov. 22	Nov. 1	Oct. 11	Sept. 20
	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$
		Nitrogen=60		
1990	(2,134.73)	(2,134.73)	(2,134.73)	(2,134.73)
1991	1,405.01	1,405.01	1,406.74	1,408.46
1992	2,973.88	2,169.49	1,534.15	1,752.33
1993	516.09	632.76	477.06	(59.35)
Total	2,670.25	2,072.53	1,283.22	966.71
		Nitrogen=120		
1990	(2,165.00)	(2,165.00)	(2,165.00)	(2,165.00)
1991	1,365.80	1,365.80	1,367.53	1,369.26
1992	3,272.60	2,400.28	1,722.05	1,952.60
1993	610.88	764.39	590.54	17.57
Total	3,084.28	2,365.47	1,515.12	1,174.43
		Nitrogen=180		
1990	(2195.07)	(2195.07)	(2195.07)	(2195.07)
1991	1,325.95	1,325.95	1,327.86	1,329.77
1992	3,563.77	2,654.99	1,927.91	2,177.15
1993	755.14	902.43	716.57	100.89
Total	3,449.79	2,688.30	1,777.27	1,412.74

TABLE 12

THYME RETURNS ABOVE ALL COSTS EXCEPT OVERHEAD, RISK, AND MANAGEMENT

YEAR	Nov. 22	Nov. 1	Oct. 11	Sept. 20
	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$	$\$ \cdot ha^{-1}$
		Nitrogen=60		
1990	(2669.04)	(2669.04)	(2669.04)	(2669.04)
1991	983.10	983.10	984.82	986.55
1992	2,551.97	1,747.58	1,112.24	1,330.42
1993	94.18	210.85	55.15	(481.26)
Total	960.21	272.49	(516.83)	(833.33)
		Nitrogen=120		
1990	(2700.25)	(2700.25)	(2700.25)	(2700.25)
1991	942.96	942.96	944.69	946.42
1992	2,849.76	1,977.44	1,299.21	1,529.75
1993	188.04	341.55	167.70	(405.28)
Total	1,280.51	561.70	(288.65)	(629.36)
		Nitrogen=180		
1990	(2731.25)	(2731.25)	(2731.25)	(2731.25)
1991	902.17	902.17	904.08	906.00
1992	3,140.00	2,231.22	1,504.13	1,753.37
1993	331.36	478.66	292.80	(322.89)
Total	1,642.28	880.80	(30.24)	(394.77)

CHAPTER V

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Farmers in Oklahoma are facing a difficult future. Traditional crops such as wheat and peanuts often have low returns unless supported by government programs. The farmer must continue to look for alternative methods to increase the return on the investment. Growing sage and thyme for processing is one alternative the farmer can use to increase the dollar return per hectare.

Sage and thyme can be produced successfully in Oklahoma. However, the combination of fall harvest date and nitrogen level is information the farmer needs to know to maximize dry weight yields and economic returns. The dry weight yield regression equations were used to discover how the harvests responded to the four fall harvest date treatments and the three levels of nitrogen. The equations were used to calculate the dry weight yield for each fall harvest date for each level of nitrogen. The yield estimations were used to calculate differences in the costs and returns for each combination of fall harvest date and level of nitrogen.

The research for the study concluded sage and thyme maximize return above total operating costs and return above all costs except overhead, risk, and management when harvested on November 22 and grown with 180 $kg \cdot ha^{-1}$ of nitrogen. This combination of fall harvest date treatment and level of nitrogen consistently had higher returns when compared with the three remaining fall harvest date treatments and two remaining levels of nitrogen. Harvesting in late November gives the highest yields and reduces the carryover damage to the plants. The November 3, 1991 freeze greatly reduced the yield for the November 1 harvest. It is recommended that the farmer harvest prior to the hard freeze or wait three weeks after the freeze. The waiting period may allow the plants to recover, but the regrowth will be a function of the weather conditions.

Recommendations

The production of sage and thyme for processing is a new idea for the Oklahoma farmer. The research done by the OSU Department of Horticulture and Landscape Architecture for growing sage and thyme for processing in Oklahoma is a great contribution to Oklahoma agriculture. The research gives the farmers another option among many to help improve their farming operation. If farmers can successfully produce sage and thyme, other manufacturers of herbs for processing could provide additional market outlets for the product. Furthermore, if production is successful and the quality of sage and thyme is consistently above imports, Kalsec, Inc. or another processor may locate an extraction facility in Oklahoma. The impact of an extraction facility on producers of sage and thyme is a relevant research topic for the future. An Oklahoma based extraction facilty could encourage production of additional herbs for processing in Oklahoma.

Until a decision is made on the location of an extraction facility, future research on sage and thyme could answer questions such as:

1. Where are the optimal locations in Oklahoma for producing sage and thyme for processing?
2. Is the optimal level of nitrogen above, below, or between the tested levels?
3. What additional markets are available for the farmers' output of sage and thyme?

This research is the first economic study of producing herbs for processing in Oklahoma. It was intended to be a foundation on which future research can build and improve. With cooperation from farmers, the OSU Department of Horticulture and Landscape Architecture, and the OSU Department of Agricultural Economics the production of herbs for processing may have a long future in Oklahoma.

REFERENCES

Adams, Patrick J. "Oil Extraction and Processing of Herbs and Spices." In Proceedings of the Second National Herb Growing and Marketing Conference, edited by James E. Simon and Lois Grant. Purdue University Department of Horticulture. July, 1987. pp 132-135.

Burns, Thomas F. "The Economic Significance of the American Spice Industry." In Proceedings of the Second National Herb Growing and Marketing Conference, edited by James E. Simon and Lois Grant. Purdue University Department of Horticulture. July, 1897. pp 127-128.

Kebede, Selashe. "Domestic Production of Paprika as Raw Spice and for Extraction." In Proceedings of the Third National Herb Growing and Marketing Conference, edited by James E. Simon and Laura Z. Clavio. Purdue University Department of Horticulture. July, 1988. pp 20-29.

Kebede, Selashe. "Domestic Production of Spices and Herbs." In Advances in New Crops, edited by Jules Janick and James E. Simon. Oregon: Timber Press, Inc, 1990. pp 489-490.

Kletke, Darrel. "Enterprise Budgets." In Agricultural Policy Analysis Tools For Economic Development, edited by Luther Tweeten. Colorado: Westview Press, Inc, 1989. p 190.

Larsen, Dennis J. "Herb Production for the Processing Industry: Reality and Opportunity." In Proceedings of the Third National Herb Growing and Marketing Conference, edited by James E. Simon and Laura Z. Clavio. Purdue University Department of Horticulture. July, 1988. pp 11-19.

Oklahoma Department of Agriculture. Oklahoma Agricultural Statistics 1991. Oklahoma Agricultural Statistics Service. 1991.

Ray, Daryll E. "Regression and Statistical Methods." In Agricultural Policy Analysis Tools for Economic Development, edited by Luther Tweeten. Colorado: Westview Press, Inc, 1989. p 17.

Simon, James E. "Essential Oils and Culinary Herbs." In Advances in New Crops, edited by Jules Janick and James E. Simon. Oregon: Timber Press, Inc, 1990. pp. 472-483.

University of Oklahoma. Oklahoma Monthly Summary November 1991. Oklahoma Climatological Survey, November, 1991.

United States Deparment of Agriculture. "U.S. Spice Trade." Foreign Agricultural Service, circular series. Selected issues.

APPENDIX

SAGE AND THYME ENTERPRISE BUDGETS

TABLE 13

SAGE FOR PROCESSING ENTERPRISE
BUDGET PLANTING YEAR

Sage for Processing, Planting Year, 180 Kg/ha N
61 Hectare-centimeters Net Irrigation
Sandy Loam Soils, Dry, Fob Farm

Operating Inputs	Units	Price	Quantity	Value
Transplants	Ha	741.000	1.000	741.00
Nitrogen (N)	Kg	0.374	180.000	67.32
Phosph (P_2O_5)	Kg	0.220	56.000	12.32
Potash (K_2O)	Kg	0.176	112.000	19.71
Planting Labor	Ha	123.500	1.000	123.50
Forage Chopper	Mg	6.620	2.270	15.03
Grinding	Mg	16.540	2.270	37.55
Rntfertsprd/acre	Ha	4.940	3.000	14.82
Bags, Tags, Etc.	Each	22.000	3.973	87.40
Drying	Mg	176.410	2.270	400.45
Forklift	Mg	11.030	2.270	25.04
Processing Labor	Hour	4.650	8.240	38.32
Hoeing Labor	Hour	4.650	75.000	348.75
Annual Operating Capital	Dol.	0.086	581.313	50.14
Machinery Labor	Hr.	4.65	25.368	117.96
Irrigation Labor	Hr.	4.65	11.860	55.149
Machinery Fuel, Lube, Repairs	Dol.			93.21
Irrigation Fuel, Lube, Repairs	Dol.			295.31
Total Operating Costs				2542.97

Fixed Costs	Amount	Value	
Machinery			
Interest at 9.25%	560.39	51.84	
Depr, Taxes, Insurance		63.36	
Irrigation			
Interest at 9.25%	1448.83	134.02	
Depr, Taxes, Insurance		138.76	
Land		148.20	
Total Fixed Costs			536.18

Production	Units	Price	Quantity	Value
Sage	Mg	882.00	2.27	2002.14
Total Receipts				2002.14

Returns above Total Operating Cost	-540.83
Returns above All Costs Except Overhead, Risk, and Management	-1077.01

Small Farm Machinery.

Kinsella Thesis
2-dec-93

Developed and Processed by Department of Agricultural Economics
Oklahoma State University

TABLE 14

SAGE FOR PROCESSING ENTERPRISE
BUDGET YEAR TWO

Sage for Processing, Year 2, November 22 Harvest
180 Kg/ha N, 61 Hectare-centimeters Net Irrigation
Sandy Loam Soils, Dry, Fob Farm

Operating Inputs	Units	Price	Quantity	Value
Nitrogen (N)	Kg	0.170	180.000	30.60
Forage Chopper	Mg	6.620	10.480	69.38
Grinding	Mg	16.540	10.480	173.34
Rentfertspr/ha	Ha	4.940	3.000	14.82
Bags,tags,etc.	Each	22.000	18.340	403.48
Drying	Mg	176.410	10.480	1848.78
Forklift	Mg	11.030	10.480	115.59
Processing Labor	Hour	4.650	38.042	176.90
Hoeing Labor	Hour	4.650	61.750	287.14
Estab Prorate	Ha	0.400	1077.010	430.80
Annual Operating Capital	Dol.	0.086	55.309	4.77
Machinery Labor	Hr.	4.65	0.908	4.22
Irrigation Labor	Hr.	4.65	11.860	55.149
Machinery Fuel, Lube, Repairs	Dol.			2.63
Irrigation Fuel, Lube, Repairs	Dol.			295.31
Total Operating Costs				3912.91

Fixed Costs	Amount	Value	
Machinery			
Interest at 9.25%	14.23	1.32	
Depr, Taxes, Insurance		1.48	
Irrigation			
Interest at 9.25%	1448.83	134.02	
Depr, Taxes, Insurance		138.76	
Land		148.20	
Total Fixed Costs			423.77

Production	Units	Price	Quantity	Value
Sage	Mg	882.00	10.48	9243.36
Total Receipts				9243.36

Returns above Total Operating Cost	5330.45
Returns above All Costs Except Overhead, Risk, and Management	4906.68

Small Farm Machinery. Kinsella Thesis
2-dec-93

Developed and Processed by Department of Agricultural Economics
Oklahoma State University

TABLE 15

SAGE FOR PROCESSING ENTERPRISE
BUDGET YEAR THREE

Sage for Processing, Year 3, November 22 Harvest
180 Kg/ha N, 61 Hectare-centimeters Net Irrigation
Sandy Loam Soils, Dry, Fob Farm

Operating Inputs	Units	Price	Quantity	Value
Nitrogen	Kg	0.374	180.000	67.32
Forage Chopper	Mg	6.620	11.030	73.02
Grinding	Mg	16.540	11.030	182.44
Rentfertspr/ha	Ha	4.940	3.000	14.82
Bags,tags,etc.	Each	22.000	18.795	413.49
Drying	Mg	176.410	10.740	1894.64
Forklift	Mg	11.030	10.740	118.46
Processing Labor	Hour	4.650	38.986	181.29
Hoeing Labor	Hour	4.650	61.750	287.14
Estab Prorate	Ha	0.400	1077.010	430.80
Annual Operating Capital	Dol.	0.086	54.128	4.67
Machinery Labor	Hr.	4.65	0.908	4.22
Irrigation Labor	Hr.	4.65	11.860	55.149
Machinery Fuel, Lube, Repairs	Dol.			2.63
Irrigation Fuel, Lube, Repairs	Dol.			295.31
Total Operating Costs				4025.40

Fixed Costs	Amount	Value	
Machinery			
Interest at 9.25%	14.23	1.32	
Depr, Taxes, Insurance		1.48	
Irrigation			
Interest at 9.25%	1448.83	134.02	
Depr, Taxes, Insurance		138.76	
Land		148.20	
Total Fixed Costs			423.77

Production	Units	Price	Quantity	Value
Sage	Mg	882.00	10.74	9472.68
Total Receipts				9472.68

Returns above Total Operating Cost	5447.28
Returns above All Costs Except Overhead, Risk, and Management	5023.51

Small Farm Machinery.

Kinsella Thesis
2-dec-93

Developed and Processed by Department of Agricultural Economics
Oklahoma State University

TABLE 16

SAGE FOR PROCESSING ENTERPRISE
BUDGET YEAR FOUR

Sage for Processing, Year 4, November 22 Harvest
180 Kg/ha N, 61 Hectare-centimeters Net Irrigation
Sandy Loam Soils, Dry, Fob Farm

Operating Inputs	Units	Price	Quantity	Value
Nitrogen	Kg	0.374	180.000	67.32
Forage Chopper	Mg	6.620	9.610	63.62
Grinding	Mg	16.540	9.610	158.95
Rentfertspr/ha	Ha	4.940	3.000	14.82
Bags,tags,etc.	Each	22.000	16.818	369.99
Drying	Mg	176.410	9.610	1695.30
Forklift	Mg	11.030	9.610	106.00
Processing Labor	Hour	4.650	34.884	162.21
Hoeing Labor	Hour	4.650	61.750	287.14
Estab Prorate	Ha	0.400	1077.010	430.80
Annual Operating Capital	Dol.	0.086	54.128	4.67
Machinery Labor	Hr.	4.65	0.908	4.22
Irrigation Labor	Hr.	4.65	11.860	55.149
Machinery Fuel, Lube, Repairs	Dol.			2.63
Irrigation Fuel, Lube, Repairs	Dol.			295.31
Total Operating Costs				3718.12

Fixed Costs	Amount	Value	
Machinery			
Interest at 9.25%	14.23	1.32	
Depr, Taxes, Insurance		1.48	
Irrigation			
Interest at 9.25%	1448.83	134.02	
Depr, Taxes, Insurance		138.76	
Land		148.20	
Total Fixed Costs			423.77

Production	Units	Price	Quantity	Value
Sage	Mg	882.00	9.61	8476.02
Total Receipts				8476.02

Returns above Total Operating Cost	4757.90
Returns above All Costs Except Overhead, Risk, and Management	4334.12

Small Farm Machinery.

Kinsella Thesis
2-dec-93

Developed and Processed by Department of Agricultural Economics
Oklahoma State University

TABLE 17

THYME FOR PROCESSING ENTERPRISE
BUDGET PLANTING YEAR

Thyme for Processing, Planting Year, 180 Kg/ha N
61 Hectare-centimeters Net Irrigation
Sandy Loam Soils, Dry, Fob Farm

Operating Inputs	Units	Price	Quantity	Value
Transplants	Ha	988.000	1.000	988.00
Nitrogen	Kg	0.374	180.000	67.32
Phosph (P_2O_5)	Kg	0.220	56.000	12.32
Potash (K_2O)	Kg	0.176	112.000	19.71
Planting Labor	Ha	123.500	1.000	123.50
Rntfertsprd/acre	Ha	4.940	3.000	14.82
Hoeing Labor	Hr	4.650	75.000	348.75
Annual Operating Capital	$	0.086	684.229	59.01
Machinery Labor	Hr	4.65	25.368	117.96
Irrigation Labor	Hr	4.65	11.860	55.149
Machinery Fuel, Lube, Repairs	$			93.21
Irrigation Fuel, Lube, Repairs	$			295.31
Total Operating Costs				2195.07
Fixed Costs		Amount	Value	
Machinery				
Interest at 9.25%		560.39	51.84	
Depr, Taxes, Insurance			63.36	
Irrigation				
Interest at 9.25%		1448.83	134.02	
Depr, Taxes, Insurance			138.76	
Land			148.20	
Total Fixed Costs				536.18
Returns above Total Operating Cost				-2195.07
Returns above All Costs Except Overhead, Risk, and Management				-2731.25

Small Farm Machinery.

Kinsella Thesis
2-dec-93

Developed and Processed by Department of Agricultural Economics
Oklahoma State University

TABLE 18

THYME FOR PROCESSING ENTERPRISE
BUDGET YEAR TWO

Thyme for Processing, Year 2, November 22 Harvest
180 Kg/ha N, 61 Hectacre-centimeters Net Irrigation
Sandy Loam Soils,dry, Fob Farm

Operating Inputs	Units	Price	Quantity	Value
Nitrogen	Kg	0.374	180.000	67.32
Forage Chopper	Mg	6.620	5.090	33.70
Grinding	Mg	16.540	5.090	84.19
Rntfertsprd/acre	Ha	2.000	3.000	6.00
Bags,tags,etc.	Each	22.000	9.366	206.04
Drying	Mg	176.410	5.090	897.93
Forklift	Mg	11.030	5.090	56.14
Processing Labor	Hour	4.650	18.477	85.92
Hoeing Labor	Hour	4.650	57.500	267.38
Estab Prorate	Ha	0.400	2731.250	1092.50
Annual Operating Capital	Dol.	0.086	104.502	9.01
Machinery Labor	Hr.	4.65	0.908	4.22
Irrigation Labor	Hr.	4.65	11.860	55.149
Machinery Fuel, Lube, Repairs	Dol.			2.63
Irrigation Fuel, Lube, Repairs	Dol.			295.31
Total Operating Costs				3163.43

Fixed Costs	Amount	Value	
Machinery			
Interest at 9.25%	14.23	1.32	
Depr, Taxes, Insurance		1.48	
Irrigation			
Interest at 9.25%	1448.83	134.02	
Depr, Taxes, Insurance		138.76	
Land		148.20	
Total Fixed Costs			423.77

Production	Units	Price	Quantity	Value
Thyme	Mg	882.00	5.09	4489.38
Total Receipts				4489.38

Returns above Total Operating Cost	1325.95
Returns above All Costs Except Overhead, Risk, and Management	902.17

Small Farm Machinery.

Kinsella Thesis
2-dec-93

Developed and Processed by Department of Agricultural Economics
Oklahoma State University

TABLE 19

THYME FOR PROCESSING ENTERPRISE
BUDGET YEAR THREE

Thyme for Processing, Year 3, November 22 Harvest
180 Kg/ha N, 61 Hectacre-centimeters Net Irrigation
Sandy Loam Soils,dry, Fob Farm

Operating Inputs	Units	Price	Quantity	Value
Nitrogen	Kg	0.374	180.000	67.32
Forage Chopper	Mg	6.620	8.760	57.99
Grinding	Mg	16.540	8.760	144.89
Rntfertsprd/acre	Ha	2.000	3.000	6.00
Bags,tags,etc.	Each	22.000	16.118	354.60
Drying	Mg	176.410	8.760	1545.35
Forklift	Mg	11.030	8.760	96.62
Processing Labor	Hour	4.650	31.799	147.86
Hoeing Labor	Hour	4.650	57.500	267.38
Estab Prorate	Ha	0.400	2731.250	1092.50
Annual Operating Capital	Dol.	0.086	286.586	24.72
Machinery Labor	Hr.	4.65	0.908	4.22
Irrigation Labor	Hr.	4.65	11.860	55.149
Machinery Fuel, Lube, Repairs	Dol.			2.63
Irrigation Fuel, Lube, Repairs	Dol.			295.31
Total Operating Costs				4162.55

Fixed Costs	Amount	Value	
Machinery			
Interest at 9.25%	14.23	1.32	
Depr, Taxes, Insurance		1.48	
Irrigation			
Interest at 9.25%	1448.83	134.02	
Depr, Taxes, Insurance		138.76	
Land		148.20	
Total Fixed Costs			423.77

Production	Units	Price	Quantity	Value
Thyme	Mg	882.00	8.76	7726.32
Total Receipts				7726.32

Returns above Total Operating Cost	3563.77
Returns above All Costs Except Overhead, Risk, and Management	3140.00

Small Farm Machinery.

Kinsella Thesis
2-dec-93

Developed and Processed by Department of Agricultural Economics
Oklahoma State University

TABLE 20

THYME FOR PROCESSING ENTERPRISE
BUDGET YEAR FOUR

Thyme for Processing, Year 4, November 22 Harvest
180 Kg/ha N, 61 Hectacre-centimeters Net Irrigation
Sandy Loam Soils,dry, Fob Farm

Operating Inputs	Units	Price	Quantity	Value
Nitrogen	Kg	0.374	180.000	67.32
Forage Chopper	Mg	6.620	3.950	26.15
Grinding	Mg	16.540	3.950	65.33
Rntfertsprd/acre	Ha	2.000	3.000	6.00
Bags,tags,etc.	Each	22.000	7.268	159.90
Drying	Mg	176.410	3.950	696.82
Forklift	Mg	11.030	3.950	43.57
Processing Labor	Hour	4.650	14.339	66.67
Hoeing Labor	Hour	4.650	57.500	267.38
Estab Prorate	Ha	0.400	2731.250	1092.50
Annual Operating Capital	Dol.	0.086	69.463	5.99
Machinery Labor	Hr.	4.65	0.908	4.22
Irrigation Labor	Hr.	4.65	11.860	55.149
Machinery Fuel, Lube, Repairs	Dol.			2.63
Irrigation Fuel, Lube, Repairs	Dol.			295.31
Total Operating Costs				2854.94
Fixed Costs		Amount	Value	
Machinery				
Interest at 9.25%		14.23	1.32	
Depr, Taxes, Insurance			1.48	
Irrigation				
Interest at 9.25%		1448.83	134.02	
Depr, Taxes, Insurance			138.76	
Land			148.20	
Total Fixed Costs				423.77

Production	Units	Price	Quantity	Value
Thyme	Mg	882.00	3.95	3483.90
Total Receipts				3483.90

Returns above Total Operating Cost	628.96
Returns above All Costs Except Overhead, Risk, and Management	205.19

Small Farm Machinery.

Kinsella Thesis
2-dec-93

Developed and Processed by Department of Agricultural Economics
Oklahoma State University

VITA 2

Anita M. Kinsella

Candidate for the Degree of

Master of Science

Thesis: A COST AND RETURN ANALYSIS FOR PRODUCING SAGE AND THYME FOR PROCESSING

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Peoria, Illinois, July 15, 1970, the daughter of John R. and Barbara L. Kinsella.

Education: Graduated from Wyoming High School, Wyoming, Illinois, in May 1988; received a Bachelor of Science Degree in Agricultural Economics from the University of Illinois at Urbana-Champaign in 1992; completed the requirements for the Master of Science degree at Oklahoma State University in December, 1993.

Professional Experience: Graduate Research Assistant, Department of Agricultural Economics, Oklahoma State University, August, 1992 to December, 1993.