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An Economic Analysis of Sequential Cropping Systems in Greenhouses in Tennessee:
Tobacco and Tomatoes

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Introduction

Current Tobacco Situation

The production of tobacco is important to the Tennessee agricultural economy. Tobacco accounted for 22 percent of all crop sales in Tennessee in 1999. Tennessee ranked third among all states in the United States in 1999 tobacco production with 122,601,000 pounds valued at $239,651,000 (Tennessee Department of Agriculture, 2000). According to the 1997 Census of Agriculture, approximately 15,000 farms produce tobacco in Tennessee (USDA). Tobacco production has been erratic over the past couple of decades, as presented in Table 1. Over this period, harvested acreage reached a high of 82,610 in 1982 and a low of 45,500 in 1989.

Table 1. All Tobacco: Acreage, Yield, Production, and Value, Tennessee, 1989-1999

Crop Year	Acreage Harvested	Yield Per Acre	Production	Marketing Year Average Price	Value of Production
		Pounds	1,000 Pounds	Dollars Per Pound	1,000 Dollars
1980	64,760	1,728	111,931	1.611	180,221
1981	78,650	2,053	161,463	1.776	286,789
1982	82,610	2,156	178,117	1.723	306,830
1983	72,910	1,621	118,197	1.797	212,428
1984	74,990	2,062	154,646	1.792	277,133
1985	61,710	2,065	127,403	1.571	200,189
1986	49,240	1,682	82,821	1.524	126,202
1987	49,440	1,766	87,291	1.551	135,421
1988	48,520	1,920	93,142	1.705	158,762
1989	45,500	1,754	79,820	1.731	138,200
1990	53,590	2,094	112,218	1.783	200,039
1991	61,730	1,969	121,524	1.834	222,837
1992	72,200	2,030	146,556	1.848	270,869
1993	69,940	1,993	139,423	1.857	258,861
1994	60,350	2,192	132,289	1.878	248,415
1995	51,690	1,797	92,907	1.912	177,667
1996	54,560	2,014	109,888	1.982	217,837
1997	59,480	1,922	114,292	1.952	223,092
1998	59,415	1,870	111,100	1.963	218,097
1999	63,170	1,941	122,601	1.955	239,651

Sources: Tennessee Department of Agriculture, *Tennessee Agriculture*, Annual Reports for 1990 and 2000

Producers inevitably face an unstable future magnified by increased government intervention into tobacco production both at the producer and consumer levels (Mundy and Witcher, 1999). They describe the impact of policies and regulations on tobacco product use in terms of long-term implications for the economic viability to the tobacco industry. Additionally, U.S. price competition and production efficiency are affected by government regulations on inputs such as migrant labor and pesticide labeling and use.

Tiller (2000) outlines issues which have contributed to the current tobacco situation in the state. Manufacturing of tobacco products is down considerably, primarily due to a decrease in cigarette consumption in response to health concerns and higher retail prices. Manufacturers are using less United States leaf in cigarettes as a result of higher leaf prices in comparison with world prices. U.S. leaf prices are substantially higher than world prices, and the quality differential advantage U.S. producers have experienced in the past is diminishing. Consequently, exports are down as a result of decreased consumption and prices.

The Economic Research Service reports the 1999 crop value of U.S. flue-cured and burley tobacco production declined $93 and $258 per acre, respectively, from 1998 (USDA, ERSa). The average yield per acre also declined as cash expenditures for production increased. The value of gross production less cash expenditures per acre experienced a decline for both flue-cured and burley tobacco.

Tennessee tobacco producers have experienced a reduction in the effective burley quota over the past three years (Tennessee Farm Bureau). For example, burley quota reductions occurred at the following rates: 1998 - 9.5 percent; 1999 - 28.7 percent; 2000 - 45.3 percent; resulting in a 65-percent effective total quota reduction since 1997. These reductions amount to a loss of 79,992,500 pounds, which represents a loss of $156,785,300 at $1.96 per pound. Burley producers have experienced increased difficulty in obtaining leased quotas due to increasing quota prices in recent years, especially in 2001. According to Kenkel, quota prices are expected to average $.50 per pound in 2001[1]. Many producers are decreasing total production, and some producers are completely ceasing production of tobacco as a result of quota reductions and reduced profitability.

Burley marketing quotas are derived from a formula including purchase intentions of tobacco companies, a 3-year export average, a reserve stock adjustment, and a value derived by the Secretary of Agriculture with a discretion which cannot exceed 3 percent upward or downward (USDA, ERS, 2000b). Quota allotments have varied over the past 20 years as shown in Figure 1. Producers are allocated a basic quota which is the amount of poundage prorated to that farm as its historical proportion of the national quota for that year. Effective marketing quota includes the basic quota as well as the carryover of poundage that was not marketed the previous year, along with any quota leased to the farm in the current year. Marketings refer to the poundage of burley tobacco that was sold either at auction or under contract (as of 2000). Figure 1 shows that marketings have been less than effective quota resulting in a carryover of potential poundage to the next year.

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[1]Personal Consultation with Dr. Phil Kenkel, Department of Agricultural Economics, The University of Tennessee, March 2001.

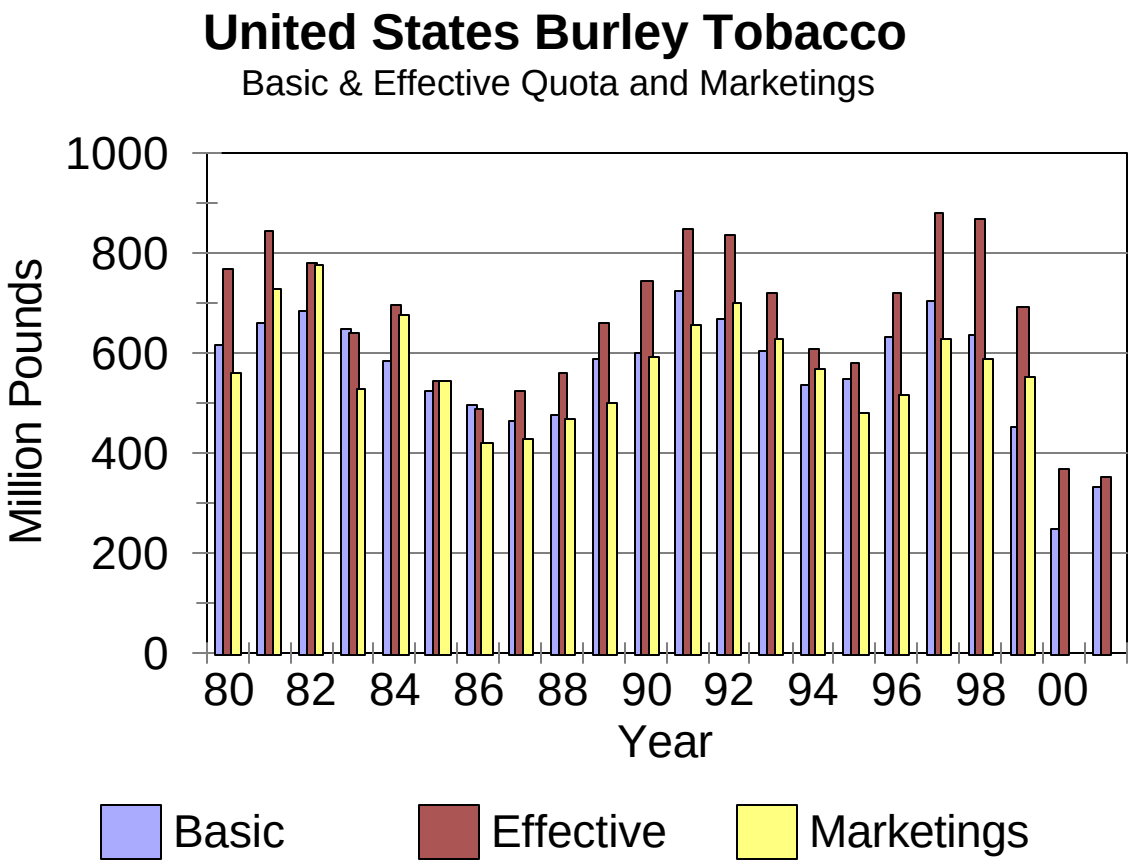

Figure 1. Comparison of Basic and Effective Quota and Marketings for United States Burley Tobacco.
Source: U.S. Department of Agriculture, ERS (c).
Marketings for 2000 and 2001 were not yet reported at the time of this research.

Producers have resources in place for tobacco production and are facing economic uncertainty because of the current tobacco situation. Many producers have greenhouse structures for producing tobacco transplants that are not fully utilized. Fowlkes[2] (2001) estimates 350 tobacco growers in Tennessee are using greenhouses to produce transplants. Given the production cycle of tobacco transplants, these greenhouses are only used three to four months a year. Smith notes, "Tobacco growers are more interested now in alternative uses for their greenhouses than ever before primarily because of the investment of the greenhouse" (Thomas, 1993, p. 33). Research is needed that provides alternative and supplemental opportunities to tobacco transplant producers that will help obtain optimal efficiency and productivity from their greenhouses, especially given the importance of tobacco to the agricultural economy of Tennessee.

[2]Personal consultation with Dr. Don Fowlkes, Plant Sciences and Landscape Systems Extension, Tobacco Specialist, The University of Tennessee, March 2001 and April 2001.

The potential profits of an alternative greenhouse production system could provide producers with options to augment their incomes while utilizing existing and/or new resources. Resource capacity and managerial capability of producing, managing, and marketing other enterprises are qualities many tobacco transplant producers possess. The production cycles of various horticultural crops could provide opportunities to expand the number of enterprises and sequential crop enterprises.

Alternative Crops

Horticultural crops provide possibilities for producers to obtain optimal efficiency from a given set of resources. Utilizing a production window between late May and January, vegetable transplants or mature vegetables appear to be the most logical alternative crop for the off-season (Thomas, 1993). Several vegetable crops have been grown in greenhouses and shown to be profitable. According to Straw[3], about 50 full-time tobacco producers have added vegetables to their farms.

Vegetable production in Tennessee has been increasing over the past ten years, expanding from 25,426 acres in 1987 to 30,303 acres in 1997 (USDA, 1992 and 1997). The farm value of vegetable production in Tennessee amounted to $49,190,000 in 1999 (Tennessee Department of Agriculture, 2000). The 1997 Census of Agriculture reported that 1,162 Tennessee farms produced vegetables (1997). Straw[4] estimates in 2000 there were over 40,000 acres of fresh market vegetables and 16,000 acres of processing vegetables grown in Tennessee. The primary fresh market crops are snap beans, tomatoes, and pumpkins.

Declining tobacco quotas and rising lease prices have increased interest in vegetable marketing cooperatives in Kentucky. Tobacco farmers are diversifying their crops and increasing their volume of produce. Crops, such as sweet corn, squash, zucchini, green peppers, cabbage, pumpkins and eggplant, will be harvested and sold through Kentucky Growers' Cooperatives in 2001. Although these crops resulted in increased acreage, the most substantial acreage increase occurred in tomatoes with some producers expanding their acreage by as much as 75 acres (Gelski, 2000).

Vegetable production is currently profitable and may prove to be a potential enterprise for domestic producers in both tobacco and vegetable production (Tomato Magazine, 2000). Many countries are exporting vegetables to the United States and increasing production as a result. In 1998, the United States imported about five times the volume of fresh tomatoes exported (Table 2). Canadian greenhouse tomatoes are imported to compete with U.S. field grown and greenhouse tomatoes. Mexico is also a primary source of imported tomatoes to compete with U.S. tomatoes.

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[3]Personal consultation with Dr. Allen Straw, Plant Sciences and Landscape Systems Extension, The University of Tennessee, April 2001.

[4]See footnote 3.

Table 2. Tomatoes: Total U.S. Fresh Market Imports and Exports, 1989-98

Year beginning July	Imports	Exports
	1,000 pounds	1,000 pounds
1989	905,428	177,177
1990	807,239	293,056
1991	460,778	343,480
1992	824,806	351,410
1993	885,824	329,577
1994	1,456,261	321,828
1995	1,702,019	288,021
1996	1,678,129	282,252
1997	1,794,809	332,416
1998	1,618,039	310,810

Source: U.S. Department of Agriculture, 1997 Census of Agriculture

Canada is a leading country in hydroponic vegetable production, and the majority of that production capacity is designated for tomatoes (Tomato Magazine, 2000). Canadian greenhouse growers expanded their exports to the United States from 21,774 metric tons in 1996 to 79,554 metric tons in 1999. Other countries, such as the Netherlands and Spain, have also increased their exports to the United States during the same time period.

According to Lucier, "Tomatoes are second only to potatoes in both U.S. farm value and vegetable consumption." The farm value of tomatoes in the United States was approximately $1.8 billion in 1999. The annual per capita use of tomatoes and tomato products has increased over 30 percent during the past 20 years and was expected to reach a fresh-weight value of 92 pounds per person in 2000. Lucier (2000) reports that per capita tomato consumption is consistent across all regions of the United States.

Tomato Industry in Tennessee

According to *Tennessee Agriculture Statistics,* 3,900 acres of field tomatoes were planted in 1999 accounting for a market value of $24 million (Tennessee Department of Agriculture, 2000) (Table 3). Tomatoes have the highest market value of all vegetable crops in the state. The actual value could be even higher because Mullins and Straw (1999) estimate the acreage in production in Tennessee to be closer to 5,500 acres annually. Production is utilized solely for fresh market sales.

Greenhouse Tomato Production

The greenhouse industry in the United States has experienced a 40-percent increase in greenhouse tomato acreage since 1996, reaching approximately 850 acres currently (MSU, Extension Service). Leading states include Colorado, Arizona, Texas, Pennsylvania, New York, California, Ohio, Tennessee, Mississippi, New Jersey, North Carolina, and Florida.

Table 3. Tomatoes, Fresh Market: Acreage, Yield, Production, and Value, Tennessee 1980-1999

Crop Year	Acreage		Yield Per Acre	Production	Marketing Year Average Price	Value of Production
	Planted	Harvested				
	Acres		Cwt.	1,000 Cwt.	Dollars Per Cwt.	1,000 Dollars
1980	3,900	3,700	110	407	21.20	8,628
1981	4,500	4,300	120	516	23.50	12,126
1982	4,500	4,300	125	538	23.10	12,428
1983	4,300	4,000	100	400	20.00	8,000
1984	4,200	3,900	200	780	23.00	17,940
1985	4,200	4,000	280	1,120	19.00	21,280
1986	4,600	4,300	210	903	20.00	18,060
1987	4,100	3,900	180	702	23.00	16,146
1988	4,200	3,900	180	702	28.00	19,656
1989	4,000	3,600	140	504	25.00	12,600
1990	4,700	4,300	200	860	24.00	20,640
1991	5,100	4,700	180	846	21.00	17,766
1992	4,800	4,500	160	720	21.00	15,120
1993	4,500	4,300	160	688	27.00	18,576
1994	4,300	4,000	230	920	27.00	24,840
1995	4,300	4,100	210	861	21.00	18,081
1996	3,900	3,700	215	796	24.00	19,104
1997	3,800	3,600	240	864	27.00	23,328
1998	3,600	3,400	250	850	38.00	32,300
1999	3,900	3,600	230	828	29.00	24,012

Sources: Tennessee Department of Agriculture, *Tennessee Agriculture* 1990 and 2000

Many greenhouse producers are predicting an increase in the greenhouse share of the U.S. tomato market due to the quality of greenhouse tomatoes (Estes and Peet, 1999). Currently, the greenhouse tomato market share is approximately 10 percent of the total tomato supplies; however, some industry leaders foresee an increase to 30 percent or more by 2005. To achieve this type of growth, producers must individually and collectively devise marketing strategies, create business plans, and primarily expand market outlets by supplying high quality products to consumers.

Greenhouse production traditionally served as a fill-in to consumer demand when field-grown tomatoes were not available (Kamberg, 1997). Today, these operations have found year-round consumers. According to Kamberg, the appearance and flavor of greenhouse tomatoes have attracted people willing to pay as much as three times the price of field-grown tomatoes. Customers view greenhouse tomatoes as being locally grown, fresher, and more flavorful. As a result, people ask for greenhouse tomatoes and are willing to pay the higher price. According to Kamberg, buyers have expressed concern regarding the scarce supply of hydroponic tomatoes due to limited quantities. Straw[5] estimates that 550 greenhouses in Tennessee are used for tomato production. The greenhouses are concentrated primarily in East Tennessee with about 450 in Grainger County alone. Tennessee's

[5]See footnote 3.

geographic location and climatic conditions have afforded several fresh-market tomato producers the opportunity to raise two crops in their greenhouses by growing both a fall and a spring crop of tomatoes in soil.

Hydroponic Tomato Production in General

Many producers are seeking alternative methods for growing their crops due to the ban of a widely used chemical (methyl bromide) that controls soil pests (UniSci). Disease-infested fields have limited production and also caused many producers to explore other methods of producing their crops. Hydroponic production achieves both objectives. Hydroponic production has higher costs, but those costs are often offset by higher yields which can be up to 10 times that of field-grown produce. Results have shown higher yields per plant from plants grown in bags than those from regular soil-grown plants.

Hydroponic plants are supplied with nutrients through a water solution. The vegetables can be grown in a variety of media including rockwool, perlite, pine bark, and sand. Hydroponically produced vegetables command a premium price due to the smoothness and perfection of fruit and the perceived association with a more organically grown vegetable. Jensen (1997) predicts a more promising future for hydroponic production than any other time over the past 50 years.

Worldwide hydroponic production amounted to less than 250 acres in 1960. Technological advances and factors, such as reduced land base, increased profit potential, and disease control, have helped expand commercial hydroponic production.

Donnan (1992b) describes several benefits associated with producing a hydroponic crop rather than a soil-based crop. These include:

- Crop yields are usually slightly higher than those obtained in good soil used in the same environment. This can be financially substantial.
- Faster crop turnaround can give further increases in yield and perhaps extend or move cropping into higher priced periods.
- Produce can have a longer shelf life.
- The soil may be unsuitable, or poorer and cheaper land can be used.
- Water usage can be much lower than with soil growing.
- Fertilizer usage can be much lower than with soil growing.
- Under hot conditions the better water availability to roots can reduce water stress on plants, giving better yields and longer plant life.
- For crops vulnerable to soil diseases, crippling losses can be substantially reduced or eliminated.
- Some crops, such as lettuce and strawberries, can be lifted from ground level to a much better height for planting, cultivation and harvesting. This gives much better working conditions and hence lower labor costs.
- Some systems require less work in setting up and planting than growing in soil.
- Weeds can be substantially reduced or eliminated.

Hydroponic production accounts for 5 percent of total greenhouse production in Tennessee (Straw[6]). Estes and Pete (1999) report that one-half of greenhouse production in North Carolina utilizes a hydroponic method of growing while the remaining growers employ the traditional soil method. The soil-less method of production accounts for 99% of greenhouse production in Mississippi (Snyder[7]). Hydroponic production systems are somewhat compatible with tobacco transplant production systems and will require only minor, if any, alterations to the greenhouse structure.

Marketing Greenhouse Vegetables

Marketing encompasses more than just selling a product (Estes and Peet). Marketing is a process which coordinates production, handling, transport, pricing, and selling activities. Growers can work with intermediaries between any of the steps involved in this marketing chain. These intermediaries could be brokers, wholesalers, or shipper/packers, who make the transition of products flow better.

Market price, production costs, and demand are three areas of concern in which producers must be knowledgeable to enter and/or survive within the dynamic, competitive fresh vegetable industry. According to Harr (2000), building a niche market with high-quality, fresh-market tomatoes is a substantial factor in the success of about 50 Grainger County farmers. Grainger County Tomatoes have built a reputation of good taste and quality and growers in that area are aware of the perception consumers have of their tomatoes. Growers have created a niche market for their product and continue to expand that market successfully. Stanley Trout, Tennessee Department of Agriculture's Marketing Director says, "We (Tennessee farmers) cannot compete in volume so we have to produce and sell taste, flavor, and quality." Part of the marketing plan is assuring customer satisfaction and providing a product year-round.

Finding or developing niche markets appears to be the significant challenge for greenhouse producers who strive to have a differentiated product that will justify a premium price. Marketing specialists in Florida are searching for "niche" markets for hydroponic farmers (Nordlie). Taking advantage of changing consumer preferences and offering a premium quality item can help growers reach a broader market base and expand into new areas, such as health-conscious and taste-conscious consumers.

Objective

The fundamental purpose of this study was to assess the feasibility of sequentially cropping vegetables with tobacco transplant production in greenhouse facilities that remain idle approximately eight months of the year. While several vegetables could offer some potential, the focus here is limited to tomatoes because of available budgetary information on tomatoes and because tomatoes are Tennessee's number one vegetable crop. The specific objective of this study was to compare the income potentials for three greenhouse alternatives at selected levels of price and yield - tobacco transplants alone, tobacco transplants and fall tomatoes, and spring and fall tomatoes.

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[6]See footnote 3.

[7]Personal consultation with Dr. Rick Snyder, Specialist, Mississippi State University Extension Service, November 2001.

Procedure

This study employed a budgetary analysis based on actual farm data and synthesized data using an economic engineering approach to evaluate the economic feasibility of sequential crop production systems in a single greenhouse. After the sequential production system was defined, data were collected and/or synthesized to identify costs associated with the system. The cost structures of the sequential cropping systems were broken down into identifiable components to allow for comparisons across production systems. This study examined three production scenarios: 1) tobacco alone, 2) greenhouses producing tobacco transplants in the spring and producing a fall crop of hydroponic tomatoes; and 3) greenhouses producing a fall crop and a spring crop of hydroponic tomatoes.

Scenario 1 involves production of tobacco transplants as a single enterprise. On average, plants should be ready for transplanting about six and one-half to eight weeks after seeding. Weather conditions can affect this time period. Transplants are usually seeded in early March and can remain in the house as late as early July.

Scenario 2 involves production of tobacco transplants and a fall crop of tomatoes. The production cycle for tobacco transplants is mentioned in the previous paragraph. The production cycle for a fall crop of hydroponic tomatoes begins with seeds being planted in a propagation house between July 5th and 10th. Tomato transplants are placed in the greenhouse in late August with fruit production beginning in mid to late October. The plants produce mature fruit for the remainder of October, November and into December. Termination of the crop usually occurs mid to late December. The greenhouse remains dormant for the following months until preparation for tobacco transplant production, beginning usually in mid-March. The house may not need to be fumigated. It can be opened in the extreme cold and closed in the extreme heat to take advantage of the extreme temperatures to help control weeds, disease, and insects.

Scenario 3 involves greenhouses where a fall crop and a spring crop of hydroponic tomatoes would be produced. A spring crop of hydroponic tomatoes is seeded in mid-November. The plants are transplanted into the greenhouse late January or by mid-February. Fruit set mid-to-late March and are produced through April, May and into June. The crop is terminated in June. The spring crop has a longer yield season than the fall crop due to earlier transplanting and better heat management. The house is dormant approximately one month in the summer and one month in the winter.

Input prices were obtained from internet catalogs of hydroponic production system suppliers and suppliers in the Knox County area. Prices for building materials, such as lumber, pipe, and hardware needed to construct the floatbeds, were obtained from suppliers of these materials in Knox County, Tennessee. Greenhouse component prices[8] are from several national suppliers of the facilities and equipment. Local greenhouse suppliers, transplant producers, and hydroponic tomato producers were consulted to obtain information regarding the building and operating costs associated with the selected greenhouse structure.

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[8]Consultation with Mr. Malcolm Holt working with SonneGro, Knoxville, Tennessee and Mr. Steve Longmire and Mrs. Kelly Longmire at Tennessee Homegrown Tomatoes, Rutledge, Tennessee.

The first type of cost considered comes from the initial fixed investment associated with each production system. Annual fixed costs usually occur when capital items are purchased and these items have a useful life of more than one production or accounting period. Therefore, these annual fixed costs come from spreading the initial investment over its useful life. Annual fixed costs include depreciation, interest, repairs, taxes, and insurance. The straight line method was used to compute annual depreciation. Also, annual repair costs were calculated as 1.5 percent of the initial investment (Kay).

Annual variable costs are separated into annual non-labor variable expenses, annual labor costs, annual interest costs on non-labor variable expenses. Annual non-labor variable expenses are expenses associated with materials (seed, fertilizer, and chemicals) that are incurred during a single production period. These expenses must occur during every production cycle because these materials are needed in production. These expenses are variable in that they have a direct relationship with the level of output.

Annual labor expense is associated with labor requirements needed for production. All labor is paid at a rate of $6.50 an hour. Based on conversations with growers in the east Tennessee area, this wage rate seems to be a reasonable base.

Variable interest charges are associated with non-labor variable expenses. These expenses must be included so the producer can account for capital invested in materials used during the production cycle. This capital could be used in another investment. The tobacco transplant and hydroponic tomato production systems are charged a 10 percent rate of interest on capital that must be received. This rate was chosen based on current rates and a conservative standard. This takes into consideration the concept of opportunity cost that every input or resource has an alternative use, even if the alternative is non-use (Kay). Total annual costs is the sum of annual fixed and variable costs. For many producers, the total annual cost of the systems is the starting point for making comparisons among various alternatives.

Production Expenses

Individual cost budgets were derived for three production systems: tobacco transplant production, fall hydroponic tomatoes, and spring hydroponic tomatoes based on using a single greenhouse. Each budget includes fixed and variable expenses. Comparisons were made among the enterprise combinations to assess the profitability of three scenarios: tobacco transplants only, tobacco transplants and fall hydroponic tomatoes, and spring and fall hydroponic tomatoes.

Greenhouse Construction Budget

A Ranger Series 30- by 144-foot greenhouse was chosen as the base size for this study. This decision was based on the premise that this size greenhouse would be suitable for both tobacco transplant production and hydroponic tomato production. While many tobacco producers currently have 96-foot greenhouses, the decision to develop budgets for the 144-foot greenhouse was influenced by anticipated economies of size with regard to vegetable production and the need for commercially marketable quantities. Many factors of production, such as the fertilization substation, are not feasible for small greenhouse operations. Producers seeking to enter the wholesale market must have a substantial amount of produce in order to establish customers and maintain that market.

Four floatbeds for tobacco transplants can be placed in the greenhouse with dimensions of 13.9 by 72 feet, holding a total of 1,464 trays of tobacco transplants. Based on allowing 4 square feet per plant and deducting 2 feet from each end of the greenhouse for clearance, a total of 1,050 hydroponic tomato plants can be grown[9].

The initial fixed investment total of $22,666.76 includes the house with no modifications for tobacco transplants or hydroponic tomatoes (Table 4). Annual depreciation of $2,266.68 was based on a zero salvage value and a 10-year useful life. Annual depreciation, repairs, and interest expenses were divided in half, and that amount was charged to each of the crop production budgets since each crop would be produced in the greenhouse approximately half of the total production period. Repairs were calculated at a rate of 1.5 percent of the initial fixed investment resulting in a $340.00 charge each year. The fixed capital required for the operation was divided in half and charged a 10-percent interest rate, amounting to $1,133.34. Total annual fixed expenses is $3,740.02. Insurance, property taxes, marketing, and packaging materials were not included in the budgets[10].

Tobacco Transplant Production Budget

The greenhouse tobacco transplant production system contains 1,464 trays that have 288 cells per tray. The usability rate adopted to estimate the number of usable transplants produced was 85 percent, which yields 358,680 usable transplants[11]. The initial fixed investment of $4,485.40 covers items needed to begin transplant production. This includes the lumber, seeding and mowing equipment, and styrofoam trays. These items were depreciated over 10 years, except for the styrofoam trays which were expected to last four years. Repairs were calculated at 1.5 percent of the initial fixed investment.

Budgets were developed for tobacco transplant production only and for tobacco transplants sequentially cropped with fall hydroponic tomatoes. The production of tobacco transplants as a single enterprise has higher costs due to the one crop bearing all the annualized costs such as depreciation, repairs, and interest values for the greenhouse (Table 5). Total annual fixed expenses result in a value of $3,583.66 and total interest expenses are $1,632.20. The primary non-labor variable expense was the coated seed accounting for $1,054.08. Expenses for electricity and propane gas were taken from Ray (1995). Labor requirements for tobacco transplant production were prorated based on labor requirements for a 35-by-96 foot greenhouse (Ray). Labor expenses included in the budget were assigned to the following tasks: installing plastic liner, 14.81 hours; seeding, 76.86 hours; clipping (3 times), 4 hours; and observation and care, 50.51 hours. Labor was paid at a rate of $6.50 per hour. Total labor charges amounted to $950.17 or $2.65 per thousand transplants.

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[9]Based on personal consultation with Dr. Carl Sams, Plant Sciences and Landscape Systems, The University of Tennessee.

[10]A North Carolina study estimated these expenses as follows: insurance and taxes @ $.05/lb., marketing @ $.07/lb, and packaging @ $.06/lb.

[11]Usability rate for floatbed production system was based on consultations with professionals at The University of Tennessee: Dr. S. Darrell Mundy, Department of Agricultural Economics and Dr. Donald Fowlkes, Extension Plant and Soil Science.

Table 4. Construction costs of a 30' x 144' Ranger Series Greenhouse

Item	Life	Units	Amt.	Unit Cost	Total Cost	Your Cost
				($/unit)	($)	
Intitial Fixed Cost						
House Cost						
Site Preparation	10	ea.	1	750.00	750.00	
House Construction	10	ea.	1	4,380.00	4,380.00	
30' x 144' Ranger 10# snow/70 mph wind	10	ea.	1	4,028.00	4,028.00	
Truss Kit for Ranger 2000	10	ea.	10	30.00	300.00	
Galvanized Steel Endwall Kit	10	ea.	2	251.00	502.00	
Aluminum Gable End Bar Kit	10	ea.	2	191.00	382.00	
Aluminum Poly Lock Device 12'	10	ea.	24	16.50	396.00	
3' x 6'8" Swing Door with Frame	10	ea.	2	185.00	370.00	
48' x 150' K-50 Poly	10	ea.	2	483.00	966.00	
8 mm Twinwall Polycarbonate Endwall Kit	10	ea.	2	200.00	400.00	
SG-2 Inflation Kit	10	ea.	1	59.00	59.00	
48" Aerotech Grower Fan (18,710 CFM)	10	ea.	2	615.00	1,230.00	
60" Aluminum Motorized Intake	10	ea.	2	319.00	638.00	
Single Stage Thermostat	10	ea.	3	38.00	114.00	
Galvanized Fan and Intake Frame Kit	10	ea.	4	79.00	316.00	
PD 225 Modine Unit Heater (225,000 BTU)	10	ea.	2	1,805.00	3,610.00	
Vent Stack Kit	10	ea.	2	135.00	270.00	
Heater Hanger Kit Roof Load	10	ea.	2	150.00	300.00	
VS-12 Schaefer Circulating Fan	10	ea.	6	139.00	834.00	
Crop Support Bracing	10	ea.	2	350.00	700.00	
2" x 6" x 12' Boards	10	ea.	48	6.87	329.76	
Ground Fiber	10	ea.	1	242.00	242.00	
Electrical Wiring	10	ea.	1	1,200.00	1,200.00	
Plumbing	10	ea.	1	350.00	350.00	
Total Initial Fixed Cost					22,666.76	
Annual Fixed Expenses						
Depreciation		yrs.	10	22,666.76	2,266.68	
Repairs		%	1.5	22,666.76	340.00	
Total Annual Fixed Expenses					2,606.68	
Interest Expenses						
Fixed Expenses		%	10		1,133.34	
Total Interest Expenses					1,133.34	
Total Annual Fixed Expenses including Interest					**3,400.02**	

Table 5. Tobacco transplant production in 30' x 144' greenhouse using floatbeds

Item	Life	Units	Amt.	Unit Cost	Total Cost	Cost per 1,000 Usable Plants	Your Cost
				($/unit)	($)	($/thousand)	
Initial Fixed Cost							
2" x 4" x 8' Boards	10	ea.	16.00	1.83	29.28		
2" x 6" x 12' Boards	10	ea.	48.00	6.87	329.76		
2" x 6" x 14' Boards	10	ea.	4.00	7.99	31.96		
Seeder and Equipment	10	ea.	1.00	270.00	270.00		
Mowing System	10	ea.	1.00	750.00	750.00		
Styrofoam Trays	4	ea.	1,464.00	2.10	3,074.40		
Total Initial Fixed Cost					4,485.40		
Annual Fixed Expenses							
Depreciation		yrs.	10.00	1,411.00	141.10	0.39	
Depreciation		yrs.	4.00	3,074.40	768.60	2.14	
Greenhouse Depreciation		yrs.	10.00	22,666.76	2,266.68	6.32	
Repairs		%	1.50	4,485.40	67.28	0.19	
Greenhouse Repairs		%	1.50	22,666.76	340.00	0.95	
Total Annual Fixed Expenses					3,583.66	9.99	
Annual Nonlabor Variable Expenses							
Coated Seed (per 10,000)		10 thsd.	42.16	25.00	1,054.08	2.94	
Potting Mix - 3 cubic ft.		bag	86.12	8.05	693.27	1.93	
20' x 100' plastic liner (6 mil)		ea.	4.00	43.49	173.96	0.49	
Fertilizer 20-10-20 (water soluble)		oz.	377.18	0.06	21.50	0.06	
Electricity		ea.	1.00	76.62	76.62	0.21	
Propane Gas		ea.	1.00	461.05	461.05	1.29	
Total Annual Nonlabor Variable Expenses					2,480.48	6.92	
Annual Labor Expenses							
Installing plastic liner		hrs.	14.81	6.50	96.27	0.27	
Seeding		hrs.	76.86	6.50	499.59	1.39	
Clipping (3 times)		hrs.	4.00	6.50	26.00	0.07	
Observation and Care		hrs.	50.51	6.50	328.32	0.92	
Total Annual Labor Expenses					950.17	2.65	
Interest Expenses							
Fixed Expenses		%	10.00		224.27	0.63	
Greenhouse Fixed Expenses		%	10.00		1,133.34	3.16	
Variable Expenses (9 Months)		%	11.00		274.59	0.77	
Total Interest Expenses					1,632.20	4.55	
Total Annual Fixed and Variable Expenses including Interest					**1,090.69**	**3.04**	

Tobacco transplant production as a single enterprise has total annul fixed and variable expenses including interest of $8,646.50 or $24.11 per thousand transplants.

Costs were substantially lower in the tobacco transplant budget sequentially cropped with fall hydroponic tomatoes (Table 6). Annual non-interest fixed expenses, including depreciation and repairs on the tobacco transplant equipment and one-half the depreciation and repairs on the greenhouse, totaled $2,280.32. Total annual fixed and variable expenses including interest is $6,776.49 or $18.89 per thousand tobacco transplants.

Spring Hydroponic Tomato Production Budget

The spring crop of hydroponic tomatoes is based on 1,050 hydroponic tomato plants in 3-gallon grow bags (Table 7). The total initial fixed investment is $2,215.13, and the items needed to begin operation are depreciated for periods of 10, 5, and 3 years. As before, repairs are calculated at 1.5 percent of the total initial fixed investment. One-half of the annual fixed expenses for depreciation and repairs are allocated to the spring crop; the other half are allocated to the fall crop. This value totals $1,531.63 per crop. Annual non-labor variable expenses consist of items needed each production cycle, such as fertilizers, grow bags, electricity, propane gas, and various other materials. The costs of these materials total $5,735.30[12]. Labor values were received from a research project directed by Dr. Carl Sams and Dr. Darrell Mundy with a private East Tennessee partner, Tennessee Homegrown Tomatoes, and synthesized values[13]. Labor expenses included in the budget are for the following tasks: general maintenance, 43 hours; transplanting seedlings, 27 hours; tying and clipping, 39 hours; pruning and leaning, 73 hours; and harvesting, 105.5 hours. Harvesting data were synthesized based on harvesting every two days beginning mid March through mid June which is the average production cycle for a spring crop of hydroponic tomatoes. Labor is paid at a rate of $6.50. Total annual fixed and variable expenses including interest are $10,137.87.

Fall Hydroponic Tomato Production Budget

The fall crop of hydroponic tomatoes includes 1,050 hydroponic tomato plants in 3-gallon grow bags, which is identical to the spring scenario (Table 8). Fixed expenses are the same as with the spring budget. Adjustments in the fertilizer inputs result in a non-labor variable expense of $5,456.95. Labor expenses are the same for the fall tomato crop as presented in the spring budget, except for harvesting. Harvesting labor decreases to 67.6 hours because the quantity harvested is lower in the fall than in the spring.

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[12]Electricity and propane gas usage was derived from information obtained from Tennessee Homegrown Tomatoes, Grainger County, Tennessee. A 40-percent price increase and extreme weather conditions caused propane gas usage to be higher.

[13]A time and motion study was conducted at Tennessee Homegrown Tomatoes during the production cycle of a spring crop of hydroponic tomatoes. Records were kept on an intricate basis regarding hours required for tasks such as general maintenance, transplanting, tying and clipping, pruning and leaning, and harvesting. The study was developed by Dr. Carl Sams, Plant and Soil Science, and Dr. Darrell Mundy, Agricultural Economics, The University of Tennessee.

Table 6. Tobacco transplant production in 30' x 144' greenhouse using floatbeds sequentially cropped with fall hydroponic tomatoes

Item	Life	Units	Amt.	Unit Cost	Total Cost	Cost per 1,000 Usable Plants	Your Cost
				($/unit)	($)	($/thousand)	
Initial Fixed Cost							
2" x 4" x 8' Boards	10	ea.	16.00	1.83	29.28		
2" x 6" x 12' Boards	10	ea.	48.00	6.87	329.76		
2" x 6" x 14' Boards	10	ea.	4.00	7.99	31.96		
Seeder and Equipment	10	ea.	1.00	270.00	270.00		
Mowing System	10	ea.	1.00	750.00	750.00		
Styrofoam Trays	4	ea.	1,464.00	2.10	3,074.40		
Total Initial Fixed Cost					4,485.40		
Annual Fixed Expenses							
Depreciation		yrs.	10.00	1,411.00	141.10	0.39	
Depreciation		yrs.	4.00	3,074.40	768.60	2.14	
Greenhouse Depreciation		yrs.	10.00	11,333.38	1,133.34	3.16	
Repairs		%	1.50	4,485.40	67.28	0.19	
Greenhouse Repairs		%	1.50	11,333.38	170.00	0.47	
Total Annual Fixed Expenses					**2,280.32**	**6.36**	
Annual Nonlabor Variable Expenses							
Coated Seed (per 10,000)		10 thsd.	42.16	25.00	1,054.08	2.94	
Potting Mix - 3 cubic ft.		bag	86.12	8.05	693.27	1.93	
20' x 100' plastic liner (6 mil)		ea.	4.00	43.49	173.96	0.49	
Fertilizer 20-10-20 (water soluble)		oz.	377.18	0.06	21.50	0.06	
Electricity		ea.	1.00	76.62	76.62	0.21	
Propane Gas		ea.	1.00	461.05	461.05	1.29	
Total Annual Nonlabor Variable Expenses					**2,480.48**	**6.92**	
Annual Labor Expenses							
Installing plastic liner		hrs.	14.81	6.50	96.27	0.27	
Seeding		hrs.	76.86	6.50	499.59	1.39	
Clipping (3 times)		hrs.	4.00	6.50	26.00	0.07	
Observation and Care		hrs.	50.51	6.50	328.32	0.92	
Total Annual Labor Expenses					**950.17**	**2.65**	
Interest Expenses							
Fixed Expenses		%	10.00		224.27	0.63	
Greenhouse Fixed Expenses		%	10.00		566.67	1.58	
Variable Expenses (9 Months)		%	11.00		274.59	0.77	
Total Interest Expenses					1,065.53	2.97	
Total Annual Fixed and Variable Expenses including Interest					**1,090.69**	**3.04**	

Table 7. Spring crop of hydroponic tomato production in 30' x 144' greenhouse sequentially cropped with fall hydroponic tomatoes

Item	Life	Units	Amt.	Unit Cost	Total Cost	Your Cost
				($/unit)	($)	
Initial Fixed Cost						
Fertilize Substation	10	ea.	1	398	398.00	
PVC pipe	10	ft.	100	0.23	23.00	
T's	10	ea.	5	0.28	1.40	
Barrels	10	ea.	3	25	75.00	
Cable	10	ft.	750	0.29	217.50	
Cable Clamps (4 per run of cable)	10	ea.	20	0.32	6.40	
Turn Buckle (2 per cable)	10	ea.	10	5.75	57.50	
Hose Nipples (3/4")	10	ea.	5	2.01	10.05	
Clamps	10	ea.	10	0.3	3.00	
Injectors	5	ea.	3	275	825.00	
Time Clock	5	ea.	1	80	80.00	
Solenoid Valves	5	ea.	3	14	42.00	
Filter - 3/4" 11 gal/min	5	ea.	2	15	30.00	
Water Line	3	ft.	720	0.124	89.28	
Spaghetti Tubing	3	ft.	2100	0.04	84.00	
Emitters	3	ea.	1050	0.26	273.00	
Total Initial Fixed Cost					2,215.13	
Annual Fixed Expenses (One-half of fixed expenses allocated to fall crop)						
Depreciation		yrs.	10	395.93	39.59	
Depreciation		yrs.	5	488.50	97.70	
Depreciation		yrs.	3	223.14	74.38	
Greenhouse Depreciation		yrs.	10	11,333.38	1,133.34	
Repairs		%	1.5	1,107.56	16.61	
Greenhouse Repairs		%	1.5	11,333.38	170.00	
Total Annual Fixed Expenses					1,531.63	
Annual Nonlabor Variable Expenses						
Transplants		ea.	1050	0.25	262.50	
Bags		ea.	1050	0.07	78.23	
Pine Bark		ea.	175	1.25	218.75	
Vine Twine		box	1	14.60	14.60	
Vine Clips		ea.	8400	0.01	106.34	
Base Fertilize (4-18-38)		lb.	787.5	0.89	700.88	
Calcium Nitrate		lb.	787.5	0.32	251.37	
Potassium Nitrate		lb.	196.875	0.34	67.57	
Magnesium Sulfate		lb.	393.75	0.24	93.56	
Insecticide		lb.	1.8	8.45	15.21	
Fungicide - Exotherm (24 per box)		box	1	103.00	103.00	
Class B Bumblebees		ea.	1	213.00	213.00	
Electricity		ea.	1	460.30	460.30	
Propane Gas		ea.	1	3,150.00	3,150.00	
Total Annual Nonlabor Variable Expenses					5,735.30	
Annual Labor Expenses						
Maintenance		hrs.	43	6.50	279.50	
Transplanting Seedlings		hrs.	27	6.50	175.50	
Tying & Clipping		hrs.	39	6.50	253.50	
Pruning & Leaning		hrs.	73	6.50	474.50	
Harvesting		hrs.	105.5	6.50	685.75	
Total Annual Labor Expenses					1,589.25	
Interest Expenses						
Fixed Expenses		%	10		110.76	
Greenhouse Fixed Expenses		%	10		566.67	
Variable Expenses (9 Months)		%	11		604.27	
Total Interest Expenses					1,281.70	
Total Annual Fixed and Variable Expenses including Interest					**3,561.09**	

Table 8. Fall crop of hydroponic tomato production in 30' x 144' greenhouse sequentially cropped with spring hydroponic tomatoes or tobacco transplants

Item	Life	Units	Amt.	Unit Cost	Total Cost	Your Cost
				($/unit)	($)	
Initial Fixed Cost						
Building	10	ea.	1	398	398.00	
PVC pipe	10	ft.	100	0.23	23.00	
T's	10	ea.	5	0.28	1.40	
Barrels	10	ea.	3	25	75.00	
Cable	10	ft.	750	0.29	217.50	
Cable Clamps (4 per run of cable)	10	ea.	20	0.32	6.40	
Turn Buckle (2 per cable)	10	ea.	10	5.75	57.50	
Hose Nipples (3/4")	10	ea.	5	2.01	10.05	
Clamps	10	ea.	10	0.3	3.00	
Injectors	5	ea.	3	275	825.00	
Time Clock	5	ea.	1	80	80.00	
Solenoid Valves	5	ea.	3	14	42.00	
Filter - 3/4" 11 gal/min	5	ea.	2	15	30.00	
Water Line	3	roll	720	0.124	89.28	
Spaghetti Tubing	3	ft.	2,100	0.04	84.00	
Emitters	3	ea.	1,050	0.26	273.00	
Total Initial Fixed Cost					2,215.13	
Annual Fixed Expenses (One-half of fixed expenses allocated to spring crop)						
Depreciation		yrs.	10	395.93	39.59	
Depreciation		yrs.	5	488.50	97.70	
Depreciation		yrs.	3	223.14	74.38	
Greenhouse Depreciation		yrs.	10	11,333.38	1,133.34	
Repairs		%	1.5	1,107.56	16.61	
Greenhouse Repairs		%	1.5	11,333.38	170.00	
Total Annual Fixed Expenses					1,531.63	
Annual Nonlabor Variable Expenses						
Transplants		ea.	1,050	0.25	262.50	
Bags		ea.	1,050	0.0745	78.23	
Pine Bark		ea.	175	1.25	218.75	
Vine Twine		box	1	14.6	14.60	
Vine Clips		ea.	8,400	0.01266	106.34	
Base Fertilize (4-18-38)		lb.	590.625	0.89	525.66	
Calcium Nitrate		lb.	590.625	0.3192	188.53	
Potassium Nitrate		lb.	147.6563	0.3432	50.68	
Magnesium Sulfate		lb.	295.3125	0.2376	70.17	
Insecticide		lb.	1.8	8.45	15.21	
Fungicide - Exotherm (24 per box)		box	1	103	103.00	
Class B Bumblebees		ea.	1	213	213.00	
Electricity		ea.	1	460.30	460.30	
Propane Gas		ea.	1	3150.00	3,150.00	
Total Annual Nonlabor Variable Expenses					5,456.95	
Annual Labor Expenses						
Maintenance		hrs.	43	6.5	279.50	
Transplanting Seedlings		hrs.	27	6.5	175.50	
Tying & Clipping		hrs.	39	6.5	253.50	
Pruning & Leaning		hrs.	73	6.5	474.50	
Harvesting		hrs.	67.6	6.5	439.40	
Total Annual Labor Expenses					1,342.90	
Interest Expenses						
Fixed Expenses		%	10		110.76	
Greenhouse Fixed Expenses		%	10		566.67	
Variable Expenses (9 Months)		%	11		560.99	
Total Interest Expenses					1,238.42	
Total Annual Fixed and Variable Expenses including Interest					**1,512.40**	

Harvesting data were synthesized based on harvesting every three days mid-October through mid-December which is the average production cycle for a fall crop of hydroponic tomatoes. Harvesting dates are less frequent in the fall because of the shorter days and less sunlight available to ripen fruit. Labor is paid at a rate of $6.50 per hour with total labor charges of $1,342.90. Total annual fixed and variable expenses including interest are $9,569.90.

Comparison of Net Returns

The decision was made to compare the budgets with the full or new cost of all factors of production. Producers who currently have used and partially depreciated greenhouses or equipment needed for production of tobacco transplants or hydroponic tomatoes can adjust expenses to reflect their unique situations. The following comparison of costs and returns were made: tobacco transplants, tobacco transplants with fall tomatoes, and spring and fall tomatoes (Table 9).

The market value assumed for the tobacco transplants is $40.00 per thousand for 358,680 usable tobacco transplants resulting in a gross revenue of $14,347.20. Producing only tobacco transplants results in net revenue of $5,700.69 or $15.89 per thousand transplants. The tobacco transplant enterprise must carry all the depreciation and interest expenses for the greenhouse. Sequentially cropping tobacco transplants with fall tomatoes results in a net revenue for the tobacco operation of $7,570.71 because greenhouse costs can be divided between both operations. Net revenue received for the fall hydroponic tomatoes when sequentially cropped with tobacco transplants is $2,801.81. Given the scenario of transplants and tomatoes, fixed expenses for tomatoes cannot be divided among the two crops therefore, the fall tomato crop must bear the entire expense.

The market value for the spring crop of hydroponic tomatoes is estimated at $1.15 per pound with an average yield of 16 pounds per plant and the fall crop is valued at $1.00 per pound and 12 pounds per plant. A sensitivity analysis was conducted and is discussed later showing values while differing yields and prices. Gross revenue from the spring crop of hydroponic tomatoes is $19,320.00 for 16,800 pounds resulting in a net revenue of $9,182.13. Gross revenue from the fall crop of hydroponic tomatoes is $12,600.00 for 12,600 pounds resulting in net revenue of $3,030.10. The combined total variable and fixed expenses including interest for the tobacco transplant / fall hydroponic tomato situation is $16,574.68 and the total revenue of the two enterprises is $26,947.20. This operation is profitable showing a net revenue of $10,372.52 less marketing costs. The net benefit of sequentially producing a fall crop of hydroponic tomatoes with tobacco transplants is $4,671.83 and is calculated by comparing the revenue of tobacco transplants with the combination of transplants and tomatoes. All net revenue values were calculated without including packaging and marketing costs.

The combined total variable and fixed expenses including interest for the spring hydroponic tomato / fall hydroponic tomato situation is $19,707.78. The combined revenue of the two enterprises is $31,920.00. This operation is profitable showing a net revenue of $12,212.22 less marketing and packaging costs. The difference in net revenue between the sequentially cropped enterprises is $1,839.70 with the spring / fall hydroponic tomato production scenario having the higher net revenue. The tomato enterprise has higher expenses, but the gross revenue received is also higher than that of tobacco transplants. Producers will also gain efficiency with the spring hydroponic tomato / fall hydroponic tomato scenario because some expenses and materials are spread between two crops.

Table 9. Annual Costs and Revenue of Combined Sequentially Cropped Enterprises not Including Packaging and Marketing Costs

	Tobacco Transplants[a]	Tobacco Transplants and Fall Hydroponic Tomatoes		Spring Hydroponic Tomatoes and Fall Hydroponic Tomatoes	
Annual Fixed Expenses	$3,583.66	$4,040.23[b]		$3,063.26	
Variable Expenses	$2,480.48	$7,937.43		$11,192.25	
Labor Expenses	$950.17	$2,293.07		$2,932.15	
Interest Expenses	$1,632.20	$2,303.95		$2,520.12	
Total Variable and Fixed Expenses Including Interest	$8,646.51	$16,574.68		$19,707.78	
Total Revenue Received	$14,347.20	Tobacco	$14,347.20	Spring	$19,320.00
		Tomatoes	$12,600.00	Fall	$12,600.00
Net Revenue[c]	$5,700.69[d]	Tobacco	$7,570.71[d]	Spring	$9,182.13[f]
		Tomatoes	$2,801.81[e]	Fall	$3,030.10[e]
Total Net Revenue	$5,700.69	$10,372.52		$12,212.22	

[a]Greenhouse depreciation, greenhouse repairs, and greenhouse fixed expenses interest are charged totally to tobacco transplants for tobacco transplant production alone.

[b]Annual fixed expenses for tomatoes are charged totally to fall hydroponic tomatoes, (excluding greenhouse depreciation and greenhouse repairs), because the annual fixed expenses (for tomatoes) are not shared with a spring hydroponic tomato crop.

[c]Fees for grading, packing, brokering, and transporting tomatoes not included, i.e., marketing expenses not covered.

[d]Net Revenue based on 85% usability rate and price $40.00 per thousand transplants.

[e]Net Revenue for fall tomatoes based on a yield of 12 pounds per plant and a price of $1.00 per pound.

[f]Net Revenue for spring tomatoes based on a yield of 16 pounds per plant and a price of $1.15 per pound.

Sensitivity Analysis

Questions concerning the sensitivity of the results to potential measurement and judgement errors are critical. This analysis allows for a better understanding of what happens to net revenue if some of the initial assumptions are relaxed. This analysis also shows what could happen if market conditions changed.

The sensitivity analysis was conducted based only on production costs and product prices for each individual enterprises. The usability rate can easily change with different management levels and changes in environment. Results in Table 10 include the net revenue for the tobacco transplant enterprise for changes in both the price per thousand and the usability rate of tobacco transplants produced as a single enterprise. Tobacco transplants produced as a single enterprise must have a higher usability rate and/or price to be profitable because all greenhouse expenses are charged to that enterprise. This situation has a negative return for some combinations of usability rate and transplant price because of higher costs of the tobacco operation. The tobacco enterprise bears all the greenhouse costs in this scenario, therefore, net revenues are lower than when tobacco transplants are sequenced with fall tomatoes.

Table 10. Net Revenue at Various Usability Rates and Price per Thousand of Tobacco Transplants Produced as a Single Enterprise

	Transplant Usability Rate				
		75%	80%	85% (Base)	90%
Price Per Thousand	$25.00	-740.75	-213.75	313.25	840.25
	$30.00	840.40	1,472.80	2,105.20	2,737.60
	$35.00	2,421.55	3,159.35	3,897.15	4,634.95
	$40.00 (Base)	4,002.70	4,845.90	5,700.69	6,532.30
	$45.00	5,583.85	6,532.45	7,481.05	8,429.65

Table 11 includes net revenues for tobacco transplants produced in sequence with fall tomatoes. Costs are not as high for the tobacco operation in this scenario because some costs are shared with the fall tomato enterprise. Given the operation size used in this study, producing tobacco transplants would still be profitable at 75-percent usability and $25.00 per thousand transplants. The net revenue of that situation would be $1,129.26.

Tomato prices change periodically as the season progresses. Table 12 shows net spring tomato revenues at various yields or average prices per pound when a tomato/tomato scenario is used. Even with lower yields and prices, the spring operation was still profitable.

The total annual fixed and variable expenses including interest less marketing and packaging costs for the fall crop of hydroponic tomatoes is less than that of the spring crop; however, both the price received and yield per plant in the fall are substantially lower than for the spring crop. The lower prices per pound result in the fall crop being less profitable. At $.60 per pound, losses resulted for the three yields assumed (Table 13). One reason to produce the fall crop, even at little or no profit, is to maintain a customer base and provide clients with tomatoes year-round, however, fall tomatoes have received a higher price than field tomatoes.

Table 11. Net Revenue at Various Usability Rates and Price per Thousand of Tobacco Transplants Produced in Sequence with Fall Tomatoes

	Transplant Usability Rate				
		75%	80%	85% (Base)	90%
Price Per Thousand	$25.00	1,129.26	1,656.26	2,183.26	2,710.26
	$30.00	2,710.41	3,342.81	3,975.21	4,607.61
	$35.00	4,291.56	5,029.36	5,767.16	6,504.96
	$40.00 (Base)	5,872.71	6,715.91	7,570.71	8,402.31
	$45.00	7,453.86	8,402.46	9,351.06	10,299.66

Table 12. Net Revenue at Various Yield per Plant and Price per Pound of Spring Hydroponic Tomatoes Produced in Sequence With Fall Tomatoes

	Total Yield			
		14,700 (14 pounds per plant)	16,800 (16 pounds per plant) (Base)	18,900 (18 pounds per plant)
Price Per Pound	$.85	2,357.13	4,142.13	5,927.13
	$1.00	4,562.13	6,662.13	8,762.13
	$1.15 (Base)	6,767.13	9,182.13	11,597.13
	$1.30	8,972.13	11,702.13	14,432.13

Table 13. Net Revenue at Various Yield per Plant and Price per Pound of Fall Hydroponic Tomatoes Produced in Sequence With Spring Tomatoes

	Total Yield			
		10,500 (10 pounds per plant)	12,600 (12 pounds per plant) (Base)	14,700 (14 pounds per plant)
Price Per Pound	$.60	-3,269.90	-2,009.90	-749.90
	$.80	-1,169.90	510.10	2,190.10
	$1.00 (Base)	930.10	3,030.10	5,130.10
	$1.20	3,030.10	5,550.10	8,070.10

Prices of needed production materials vary over time resulting in higher or lower costs. Interest rates also vary over time; therefore, producers need to make adjustments based on current rates. Interest rates also vary based on an individual's credit rating and whether the loan will be secured or unsecured.

Conclusions and Implications for Further Research

The results of this study suggest that sequentially cropping tobacco transplants and fall hydroponic tomatoes, or spring hydroponic tomatoes and fall hydroponic tomatoes are viable options to extending the growing season and attaining greater efficiency and profitability with greenhouses. Both scenarios result in positive net returns; however, the cropping system of spring hydroponic tomatoes and fall hydroponic tomatoes has the higher net revenue. Environmental factors, consumer preferences, and prices can alter the results given the dependency each crop has on these factors. Actual net returns may be reduced substantially by the expenses associated with marketing tomatoes which are higher than for tobacco.

Both combination scenarios resulted in a profit for the operation, but on an individual basis, the fall hydroponic tomato budget showed a relatively low net return raising questions about the feasibility of the crop. Producers can potentially make a higher return on the fall crop if prices are higher, yields are higher, or both. Another consideration for producers who were already in greenhouse production is the lower expenses for the greenhouse. With lower greenhouse costs, the fall crop will be more profitable.

Tobacco Transplants / Fall Hydroponic Tomatoes

The profit for the tobacco transplant / fall hydroponic tomato scenario is $10,372.52[14]. The tobacco transplant operation has a net revenue of $7,570.71 resulting in a net benefit when producing in a sequential cropping system. The producer must incur all costs for the hydroponic tomato production and cannot spread them across two crops within the same year. Given the projected price and yield values, it appears potentially profitable and feasible for a producer to grow tobacco transplants in the spring and hydroponic tomatoes in the fall under the conditions specified in this study. However, if marketing costs for tomatoes are substantial, potential profitability for tomatoes is questionable.

Some producers may experience lower costs and thus attain higher net revenues if they currently own their greenhouses. For this study, costs based on new construction were assumed for all enterprises for the purpose of comparing the entire operation. Producers who currently own or have access to materials or used equipment needed for production can decrease some cost values in the budget by making the appropriate adjustments for their situations.

Spring Hydroponic Tomatoes / Fall Hydroponic Tomatoes

The profit for the spring / fall hydroponic tomato scenario is $12,212.22. Producers may look at the low net return obtained with the fall crop in a different way if they also produce a spring crop of tomatoes. If market outlets can be established for spring tomatoes, then producers may consider fall production to maintain their customer bases by supplying tomatoes over a longer time period. As the

[14] Adjustments were made in Table 8 to accurately reflect values of producing a fall crop of hydroponic tomatoes as a single enterprise. Annual fixed expenses were doubled and greenhouse fixed expenses were doubled.

market is developed and strengthened, the hydroponic method of production perfected, and quality is enhanced, net returns could possibly improve for the spring and the fall crops. Because the overall market price is continuously being discovered as the forces of supply and demand interact, profitability and the level of returns will most certainly change from year to year.

Producers with existing greenhouses may also incur substantially lower total costs than those in the budgets presented in this study. The greenhouse operation also increases in efficiency when producing a spring and fall crop of tomatoes because several fixed costs are spread over two crops instead of one.

Implications for Further Research

This study was undertaken to help tobacco transplant producers evaluate costs and revenues of sequentially producing tomatoes and tobacco transplants in a single greenhouse. Given the current tobacco situation, producers are seeking information on alternative crops. Research examining additional vegetable crops and various multiple cropping schemes would be beneficial for current producers.

Another issue which needs additional research is the optimal greenhouse size for various crops and sequenced crops. Research is currently available on the optimal size for a greenhouse producing tomatoes, but little research has been done in the area of sequentially cropping and at what level of each crop is the most efficient. Also, research to facilitate production of a crop(s) throughout the year is needed. If viable, year-round production could substantially reduce average variable costs and provide a more stable employment opportunity for hired labor. Such studies would require consideration of complex weather conditions and market outlet issues that would confront the producers.

Costs associated with marketing tomatoes were not included in this research. The fruit and vegetable market is volatile and unpredictable and is not a stable market. The structure for this market is unlike that of tobacco in which there is government subsidization in the form of a price floor. The production of tomatoes involves more risks and a higher level of management due to the sensitivity and degree of accuracy associated with tomatoes. The grades and standards of fruits and vegetables are much higher and not well defined across the industry. Aspects of marketing which were not included in this study are packaging, advertising, labeling, and other post harvest handling activities and expenses. Further research could address these costs and analyze the impact of marketing costs on the revenue of the tomato crops.

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