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The Economic Potential of Vegetable Production for Limited Resource Farmers in South Central Alabama

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The objective of this study was to evaluate the potential of vegetable production to enhance the declining farm income of limited resource farmers. A survey of 60 limited resource farmers in south central Alabama was undertaken to carry out this evaluation. Results of the survey show that 95% of the farmers had an annual farm income of less than $12,000. Linear programming methodology was applied to perform a whole-farm analysis of a representative farm developed from the data. The overall results show that vegetable production will significantly increase the annual income of these farmers. Some specific conclusions are that: (*a*) the total return from vegetable production depends on vegetable mixes; (*b*) vegetable production is labor intensive and sensitive to change in labor cost, implying that an increase in minimum wage might affect the return from vegetable production; and (*c*) development of labor-saving technology in vegetable production could be considered as a long-term solution to increase the returns of vegetable producers.

Key Words: enterprise budget, farm analysis, farm income, limited resource farmers, linear programming, minimum wage, vegetable production

The decline in farm income of limited resource farmers and the economic well-being of rural communities has been a focus of extensive study for the last three decades. The main sources of farm income for small and limited resource farmers in the southern United States are livestock production, vegetables, and nonvegetable crops (Demissie; Dismukes, Harwood, and Bentley). From 1986–96, the commercial production of vegetables in general, and fresh vegetables in particular, increased at an annual rate of 5% [U.S. Department of Agriculture/National Agricultural Statistics Service (USDA/NASS), 1997]. This rise in production was induced by growing public demand, driven in large part by enhanced consumer awareness of the dietary and health benefits of fresh vegetable consumption (Hamm; Smallwood and

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Blaylock; USDA, 1998). Sales of vegetables increased from $13.9 billion in 1994 to $15 billion in 1997, and were projected to increase to $16.8 billion in 1998 (USDA, Interagency Agricultural Agency Projections Committee, 1998). Given the recent demand for fresh vegetables, vegetable production could be a viable economic alternative for raising the farm income of limited resource farmers.

The long growing season in the southern U.S. makes it particularly suitable for the production of horticultural crops, though drought, diseases, and pests can be negative factors. Agricultural production in many southeastern states has changed dramatically in recent years, and farmers—especially moderate and small farmers—have retreated from the production of field crops such as cotton and peanuts, and from dairy, to vegetable crops and soybeans (Estes). A regional analysis by Epperson and Lei of vegetable production in Georgia, North Carolina, and South Carolina reported that vegetables and small fruit were promising alternatives for limited resource farmers. Zwingli et al., and Zwingli, Hardy, and Adrian studied the potential of vegetable production in northern Alabama, with implications for other southeastern vegetable-producing regions. The findings of their studies suggest a strong market potential at the national wholesale market level for fresh vegetables. From 1989–95, the revenue from marketing of vegetables increased by 14% in the state of Alabama (Alabama Department of Agriculture and Industries, 1997).

Our evaluation of the potential of vegetable production in south central Alabama was based on the assumption that producers can find buyers for their produce at the wholesale level. The proximity to Atlanta, New Orleans, and St. Louis terminal markets also promises expanded markets for the produce from Alabama. The trend of increasing revenues from vegetables gives some indication that vegetable production may provide a revenue source to limited resource farmers. However, the profitability of each vegetable crop and vegetable mix must be investigated to facilitate the decision-making process of those limited resource farmers considering vegetable production.

The primary purpose of this study is to analyze the potential of vegetable production on farm revenue. Specific objectives are: (*a*) to compare the relative level of average cost/return per acre of vegetable crops, and (*b*) to determine the vegetable mix that can maximize the return to the farmers, subject to the impacts of changes in the availability and price of labor and capital on the farm income. This study uses data from a survey of 60 south central Alabama limited resource farmers and annual average prices for the selected vegetable crops taken from the USDA/Agricultural Marketing Service (AMS) Federal-State Market News Service regional reports. Average prices eliminate some of the market variation; however, risk and sensitivity analysis are addressed later in the article.

In the section that follows, we describe the methodology and models used in this study. Data and estimation procedures are then discussed, followed by a presentation of the results and the final section offering our conclusions.

Methodology and Models

Enterprise Budget Analysis

Enterprise budget analysis was conducted to evaluate the net returns of the different cropping systems on farm income. Average return per acre was calculated from enterprise budgets, and the return per acre was used to evaluate the relative potential of each vegetable crop to increase farm income. However, average return of each vegetable crop is a limited measure of profitability. To identify the combined effect of all the vegetables to total return, the enterprise budget was used to develop a whole-farm analysis.

Linear Programming Model

A linear programming (LP) model (Hazell and Norton) was developed to simulate the optimal vegetable production mixes under various scenarios based on the current farming practices of our sample farmers. The base model was also altered to analyze the sensitivity of the results to changes in the quantity and price of labor and capital as well as the change in vegetable market price. The model maximizing the return from an alternative vegetable mix subject to labor and capital constraints can be expressed mathematically as follows:

(1) $$\text{Max } \pi = \sum_i P_i X_i - WL - RK,$$

subject to:

(2) $$\sum_i X_i \leq LD,$$

(3) $$\sum_i AL_i X_i - L = 0,$$

(4) $$L \leq LB,$$

(5) $$\sum_i AK_i X_i - K = 0,$$

(6) $$K \leq KT,$$

and

(7) $$X_i \geq 0, \quad \forall\, i,$$

where

π = economic return of vegetable production,
i = type of vegetables/crops (i = 1, 2, 3, ..., n),
X_i = acreage of the land allocated for vegetable i,
P_i = total revenue per acre of vegetable i,
W = per hour labor cost (wage rate),
R = capital cost (interest rate),
AL_i = amount of labor required for one acre of vegetable i,
L = total amount of labor required for all vegetable production,
AK_i = amount of capital required for one acre of vegetable i,
K = total amount of capital required for all vegetable production,
LD = total number of acres available,
LB = total amount of labor available, and
KT = total amount of capital available.

Equation (1) is the objective function that maximizes the return of vegetable production on the farm. Equation (2) represents the land area constraint. Equations (3) and (5) serve as the accounting equations for labor and capital, respectively. The limit on the availability of labor and capital is imposed, respectively, by equations (4) and (6). Equation (7) is the nonnegativity constraint.

Data and Estimation Procedures

The primary source of data for this study was a 1997 survey of 60 sample farmers in south central Alabama. The survey sample used to define a "typical" operation was drawn from respondents classified as limited resource farmers and receiving assistance from the USDA. The survey instrument included questions related to farm household characteristics, crop mix, labor use, capital use, marketing practices, and household income. The survey results were supplemented by data from Tuskegee University Cooperative Extension, Auburn University Cooperative Extension, and the USDA/AMS Federal-State Market News Service regional reports.

Data on costs and returns per acre, and the list of vegetables considered in the analysis are given in table 1. Cost and return data were computed using the 1992 enterprise budgets for vegetable crops developed by the Alabama Cooperative Extension Service at Auburn University, and fob prices from USDA/AMS Market News Service reports of the regional offices in Atlanta and Thomasville, Georgia. Production cost used in the study included purchased input costs (variable costs) and labor cost. The purchased inputs—including seed, fertilizer, insecticides, herbicides, tractor/machinery time, storage, grading, and hauling—were used as a proxy for capital used by the farmers. Cost of land was not included in total cost because the majority of the farmers owned their land. Net return was computed as revenue minus total cost (where net return was return to land, fixed capital, overhead, management,

Table 1. Costs and Returns of Vegetable Production by the Sample Farmers in South Central Alabama, 1997 ($)

Vegetables	Gross Revenue[a]	Costs: Labor: Harvesting	Costs: Labor: Other	Costs: Capital	Net Return
Sweet potatoes	3,325	309	237	1,377	1,402
Collard greens	1,116	211	111	429	365
Turnip greens	1,200	211	111	429	449
Okra	2,400	1,442	128	533	297
Southern peas	1,500	360	88	339	713
Watermelons	2,400	185	117	336	1,762

Source: "1992 Budgets for Vegetable Crop Enterprises in Alabama," Alabama Cooperative Extension Service, Auburn University.

[a]Gross revenue was computed using yield per acre from the 1992 enterprise budgets and the 1997 shipping point prices from USDA/AMS Federal-State Market News Service, Atlanta and Thomasville, Georgia, and from Market News Online Service.

and risk). The whole-farm model was used to measure the returns of the various vegetable enterprises.

The LP model was run using GAMS (Brooke, Kendrick, and Meeraus). In addition to the base model representing the current average farm, sensitivity analysis was also conducted to simulate impacts of changes in the price and availability of labor and capital and vegetable market price on the optimal vegetable mix.

Results and Discussion

Questionnaire results show that the mean age of the farmers surveyed was 53 years. The average farmer was married with one child under 20 years of age. The three members of the family (farmer, spouse, and child) were the source of family labor. Livestock was produced by the majority of the farmers. The different crops produced by the farmers were collard greens, corn, mustard, okra, peas, soybeans, squash, sweet potatoes, turnip greens, and watermelons, as well as a very small quantity of cucumbers and tomatoes. The average farm size was about 107 acres. Approximately 13% (14 acres) of the total land was allocated for production of vegetable crops. Livestock (primarily beef) production took about 20% of the land, and the remaining 67% was used for production of other crops (mainly corn and soybeans). Most farmers cultivated part of their land.

Vegetables produced by 20% or more of the farmers were used to develop the representative farm model (the base model). To avoid complexities, production of row crops and livestock was exogenously determined and the study focused on vegetable production. The vegetables to be considered for production by the representative farm included okra, southern peas, watermelons, sweet potatoes, turnip greens, and collard greens. Although collard greens were produced by only 13% of the farmers, this crop was included in the model farm to avoid limiting the production of greens to turnip greens for consumers and wholesalers who might require a variety of greens.

A total area of 14 acres was used for vegetable production by the representative farm, with specific allocations for the six vegetable crops as follows: five acres for watermelons, three acres for southern peas, two acres for okra, 1.5 acres each for collard and turnip greens, and one acre for sweet potatoes. The harvest calendar for these vegetables extends throughout the growing seasons of the year—spring, summer, and fall. Turnip and collard greens are available throughout the year, except summer. Watermelons are harvested in late spring to early summer, sweet potatoes from August to November, okra during summer and early fall, and southern peas from July until the end of September (Zwingli et al.; Alabama Department of Agriculture and Industries/Farmers Market, 1998).

Both family and hired labor were used in production. Hired labor was used for farming activities requiring more than 40 hours a week. On average, 53% of labor was supplied by the farm household, and the remaining 47% was supplied by hired labor. The Alabama Department of Agriculture planting and harvesting calendar shows that land preparation and planting time runs from March to May, and harvesting runs from June to November. Hired labor was primarily used during the harvesting period. Harvesting time overlapped for most of the vegetables, which increased the total amount of labor needed during the period.

Loans accounted for about 63% of the capital used by the farmers surveyed, and 37% of capital originated from farmers' own funds. The mean capital was about $11,100. Approximately 80% of the farmers had a total gross household income of less than $25,000 per year. Total household income was composed of on-farm and off-farm sources. The sources of off-farm income were mainly wages and salaries from employment and transfer incomes. Farmers were employed on a part-time basis and off-season. The on-farm component of income ranged from 40% to 62% of total household income, with the on-farm income for our sample ranging from $5,000 to $12,000.

Enterprise Budget Analysis Results

Table 1 shows labor cost, capital cost, gross revenue, and net return over variable cost per acre for the vegetables in the model farm. Watermelon production generates the highest return of $1,762 per acre, followed by sweet potatoes at $1,402. Southern peas yield $713 per acre. Collard and turnip greens have the same total labor and

Table 2. Summary of Different Scenarios Analyzed by the Linear Programming Models

Model	Land Area (acres)	Labor Cost ($/hour)	Interest Rate (%)	Price	Impact
Base	14	5.50	9	Current	Base
Scenario 1	14	5.50	6	Current	Interest
Scenario 2	14	6.50	9	Current	Labor cost
Scenario 3	14	6.50	6	Current	Interest & labor cost
Scenario 4	14	5.50	9	↓ 5%	Price
Scenario 5	14	5.50	9	↓ 10%	Price
Scenario 6	14	5.50	9	↑ 5%	Price
Scenario 7	14	5.50	9	↑ 10%	Price

capital requirements, but turnip greens generate a net return of $449 per acre while collard greens obtain $365 per acre. Okra produces the lowest net return, even though its gross return is the second highest and comparable to watermelon production.

Okra has the highest total cost per acre of all the vegetables in the model, and watermelon has the lowest. Labor cost accounts for 52% of total cost for the vegetables in the model, with the exception of okra whose labor cost accounts for 75%. Average harvesting cost for vegetables in the model accounts for about 65% of total labor cost, except for southern peas and okra at 80% and 92%, respectively. Capital cost is the cost for purchased inputs, mainly chemical inputs, machinery, and other variable costs. Capital cost is lower than 50% of total cost of production, except for sweet potatoes where capital cost accounts for 72% of total cost. The major capital cost in sweet potato production is the cost of storage, grading equipment, and machinery. Okra requires more capital than any other vegetable in the model except sweet potatoes.

Simulation Model Results

Eight separate linear programming models were solved (detailed in table 2). The first model represents the existing basic conditions, the representative farm. The six vegetables included in the representative farm model were watermelons, sweet potatoes, southern peas, turnip greens, collard greens, and okra. The farm produced 14 acres of vegetables that were sold at local markets, roadside stands, farmers markets, spot markets for wholesalers and brokers, or through contracting to wholesalers and brokers. The supply of family labor was constrained to the three family members, but there was no limit on hired labor. The land constraint was limited by the current acres allocated to each vegetable. In the base model, about 63% of the operating capital was borrowed and the remaining 37% was the farmer's own funds. The interest rate on borrowed capital was assumed to be 9% per year. This farm situation was used for comparative analysis. The interest rate was reduced to 6% in Scenarios 1 and 3 (table 2) based on the current reduction of the market interest rate and assuming government-subsidized loans. The increase in hourly wage rate from $5.50 to $6.50 (Scenarios 2 and 3) was based on the anticipated increase in minimum wage.

The results of the basic model and the different scenarios are detailed in table 3. The model farm solution generated a net return over variable costs of $13,056. The vegetable production required a capital of $6,428 and labor of 1,461 hours. All the land was utilized, and the shadow price of land was $144. The shadow price is the marginal value product of the last input brought into production. The shadow price of land showed that vegetable production will generate a substantial benefit to farmers compared to current land rent, which is about $45 per acre in south central Alabama. The marginal values of the vegetables produced under the base model were as follows: $1,567 for watermelons, $1,098 for sweet potatoes, $510 for southern peas, $244 for turnip greens, and $160 for collard greens. As shown in table 3, okra production under this model broke even, which reflects that the production of okra did not cover the cost of management, overhead, and fixed capital. Because okra production utilizes relatively more capital and labor than the other vegetables in the model, okra will become more profitable only if a significant reduction in cost occurs in the production process.

Scenario 1 (table 3) shows the effects of a reduction in interest rate from 9% to 6%. The net return changed from $13,056 in the base model to $13,249, an increase of less than 1%. Scenario 2 shows the result of an increase in the minimum wage from $5.50 to $6.50 per hour, holding the interest rate at 9%. The return declined from $13,056 for the base solution to $11,922. Compared to the base model, the marginal values for watermelons, sweet potatoes, southern peas, turnip greens, and collard greens increased, and the marginal value for okra became negative (dropping to −$163). Okra's negative value indicates that with an increase in labor cost, the production of one acre of okra will reduce the total return by $163.

Scenario 3 (table 3) was developed to show the simultaneous effect of a reduced interest rate (6%) and an increased minimum wage ($6.50/hour) on farm return. Findings show that the net return declined from $13,056 in the base model to $12,083. This decline could be attributed to the negative marginal value of okra (−$147). When compared with the results of Scenario 2, there was a slight increase in the net farm return for Scenario 3. Although none of the marginal values for vegetables increased significantly, the somewhat larger increase in the marginal value of sweet potatoes could account for the slight change in the total net return for Scenario 3. The increase in the marginal value of sweet potatoes under this scenario indicates this vegetable used the largest volume of capital among the vegetables in the model, and consequently could be adversely affected by an increase in capital cost. The results for this scenario also reveal that the reduction in interest rate did not encourage the use of more capital or compensate for the increase in labor cost.

The base model was reestimated allowing the linear programming model to select the vegetable that would maximize return without constraints on acreage allocated to a specific vegetable, hired labor, or loan. The results show that only watermelon remains in the solution and generates a larger return ($24,070) to the farm than any of the alternative scenarios. All 14 acres of available land were used for the production of watermelon. This scenario meets the objective of maximizing return only; yet, other than merely achieving the highest return, farmers also must diversify their activities to reduce risks and balance work and revenue throughout the year.

Scenarios 4, 5, 6, and 7 provide the price-sensitivity analysis to account for seasonal price variability and risk. Vegetable prices decline over harvest season and pick up off-season. The seasonal price variation has an impact on farmers' annual average income. Risks associated with the overall price variability of the vegetables in the model were measured using a coefficient of variation, with the following results: 0.29 for sweet potatoes, 0.27 for watermelons, 0.15 for turnip greens, and 0.03 for okra and southern peas. A higher degree of price variability associated with sweet potatoes, watermelons, and turnip greens is consistent with the findings of Zwingli et al. The same study also found that okra exhibited a reduced risk attached to price.

Price sensitivity was examined using a 5% (Scenario 4) and 10% (Scenario 5) price decrease, as well as a 5% (Scenario 6) and 10% (Scenario 7) price increase. These percentages were based on the results of a regression using the price data of the different vegetables from 1993–97.

The decline in price by 5% and 10% (Scenarios 4 and 5, respectively, table 3) resulted in a decline in return as expected. With a price reduction of 5% (Scenario 4), the marginal value of watermelons was not affected, while the marginal value of sweet potatoes declined. The marginal values of the remainder of the vegetables indicated an increase, with collard greens generating the highest increase. At a price reduction of 5%, the shadow price of land declined to $21 from $144 in the base model. Under a price decline of 10% (Scenario 5), the marginal values of watermelons and sweet potatoes declined significantly, while marginal values of turnip and collard greens increased, okra was negative, and the shadow price of land dropped to zero. Under this scenario, it is not profitable for farmers to use all the land. Overall, farmers can still make some profit with a 5% decline in prices (Scenario 4). Watermelons are the least affected by the price decline, but it might not be profitable for farmers to produce okra. A decline in prices of 10% or more, however, will significantly affect farmers' income.

Scenarios 6 and 7 indicate an increase in price by 5% and 10%, respectively. Compared to the base model, the marginal value of sweet potatoes was the highest for both price increases, while the marginal values of watermelons and okra remained the same. At a 5% price increase, the marginal value of turnip greens increased, while marginal values of southern peas and collard greens declined. The

Table 3. Optimal Crop Mixes for an Average Farm Under Different Scenarios

Model / Crop Mix	No. of Acres	Net Return ($)	Marginal Value ($/acre)	Capital Used ($)	Labor Used (hours)	Land Used (acres)	Shadow Price of Land ($/acre)
BASE:		13,056		6,428	1,461	14	144
Watermelons	5.0		1,567				
Sweet potatoes	1.0		1,098				
Southern peas	3.0		510				
Turnip greens	1.5		244				
Collard greens	1.5		160				
Okra	2.0		0				
SCENARIO 1:		13,249		6,428	1,461	14	157
Watermelons	5.0		1,561				
Sweet potatoes	1.0		1,123				
Southern peas	3.0		504				
Turnip greens	1.5		244				
Collard greens	1.5		157				
Okra	2.0		0				
SCENARIO 2:		11,922		5,362	851	12	0
Watermelons	5.0		1,650				
Sweet potatoes	1.0		1,134				
Southern peas	3.0		564				
Turnip greens	1.5		322				
Collard greens	1.5		238				
Okra	2.0		-163				
SCENARIO 3:		12,083		5,362	851	12	0
Watermelons	5.0		1,660				
Sweet potatoes	1.0		1,175				
Southern peas	3.0		575				
Turnip greens	1.5		335				
Collard greens	1.5		251				
Okra	2.0		-147				
SCENARIO 4:[a]		11,795		6,428	1,461	14	21
Watermelons	5.0		1,567				
Sweet potatoes	1.0		1,052				
Southern peas	3.0		550				
Turnip greens	1.5		304				
Collard greens	1.5		266				
Okra	2.0		0				

(continued . . .)

Table 3. Continued

Model / Crop Mix	No. of Acres	Net Return ($)	Marginal Value ($/acre)	Capital Used ($)	Labor Used (hours)	Land Used (acres)	Shadow Price of Land ($/acre)
SCENARIO 5:[b]		10,502		5,362	851	12	0
Watermelons	5.0		1,469				
Sweet potatoes	1.0		906				
Southern peas	3.0		509				
Turnip greens	1.5		265				
Collard greens	1.5		229				
Okra	2.0		-98				
SCENARIO 6:[c]		14,530		6,428	1,461	14	261
Watermelons	5.0		1,567				
Sweet potatoes	1.0		1,144				
Southern peas	3.0		465				
Turnip greens	1.5		284				
Collard greens	1.5		142				
Okra	2.0		0				
SCENARIO 7:[d]		15,491		6,428	1,461	14	381
Watermelons	5.0		1,567				
Sweet potatoes	1.0		1,190				
Southern peas	3.0		420				
Turnip greens	1.5		124				
Collard greens	1.5		82				
Okra	2.0		0				

[a] Scenario 4 reflects a 5% price reduction.
[b] Scenario 5 reflects a 10% price reduction.
[c] Scenario 6 reflects a 5% price increase.
[d] Scenario 7 reflects a 10% price increase.

declines could be related to the shifting of resources to production of watermelons and sweet potatoes which generated higher returns.

Conclusions

Limited resource farmers in south central Alabama grow a variety of vegetables, and vegetable production has the potential to enhance farm income. The potential for increase in income from vegetable production depends on several factors—primarily availability of resources, management, and market availability. With close proximity to farmers markets and wholesale terminal markets in Atlanta and New Orleans, this study assumes market accessibility for Alabama producers. The results of a linear programming model using six selected vegetables (sweet potatoes, watermelons, okra, collard greens, turnip greens, and southern peas) show that the production of these vegetables will increase farm income, with watermelons and sweet potatoes generating the highest returns.

Production, harvesting, and marketing can extend year round. If production is well coordinated, income may be generated throughout the year. Watermelons have low production cost and a reasonable income potential. Collard greens and turnip greens show production potentials throughout the year, with a lower production cost than sweet potatoes and southern peas. Okra has good return, but high harvest and handling labor requirements. Labor cost created a major constraint in vegetable production by small and limited resource farmers. Due to this constraint, okra may not be the best vegetable to produce. Production of vegetables is more sensitive to changes in labor cost than to changes in interest rates. An increase in labor cost appears to have a major impact on the return from vegetable production, especially for okra and sweet potatoes, under the current conditions. Therefore, an increase in the current minimum wage will have some negative impact on the profitability of small and limited resource vegetable producers who hire labor to meet their production needs.

The results of this study are short run in nature and bounded by the assumptions and limitations imposed. Thus, caution must be used in their interpretation. Many factors are involved in obtaining an accurate function of the price and cost assessment. The total long-run effect of non-okra production may not be known with certainty. The estimated return can be used as an estimate of the short-run level of expected return; however, changes in market prices or costs could significantly alter the results. Nevertheless, these findings provide some helpful information for better understanding the potential economic returns of various vegetable production scenarios and possible impacts of changes in factor prices on farm return. Results of this investigation suggest that production of properly selected vegetables is profitable and offers a viable economic option for enhancing the income generation of small and limited resource farmers in Alabama.

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