REDUCED RISK ROTATIONS FOR FRESH VEGETABLE CROPS: AN ANALYSIS FOR THE SAND MOUNTAIN AND TENNESSEE VALLEY REGIONS OF ALABAMA

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Abstract

A mixed integer linear programming model was developed to simulate the decision environment faced by an entry-level vegetable producer contemplating production for the wholesale market. The model included activities which permitted consideration of 13 vegetable crops within a spring, summer, and fall rotational system. Rotations were permitted within given bounds established by marketing, rotational, and price risk constraints. Rotations were generally stable with respect to markets and relative to crop mixes as target income and acceptable negative deviation levels were varied. Spring and fall broccoli and turnip greens and late spring-summer yellow and zucchini squash were dominant crops in the triple crop rotations in the Atlanta and Cincinnati markets.

Key words: vegetables, risk, multi-cropping systems, MOTAD, markets, feasibility.

The Sand Mountain and Tennessee Valley regions which occupy the northern one-third of Alabama have historically included some fresh vegetable production. With the recent depressed prices for more traditional agricultural products, a number of farmers in the area have indicated increased interest in fresh vegetable production. Relatively high prices for some vegetable crops indicate possibilities for profitable production. If producers are to make reasonable decisions relative to the feasibility of alternative vegetable crops, they must consider the production, marketing, and risk components of these enterprises.

In the past, evaluation of alternative vegetable enterprises has primarily been conducted in the context of "market window" analysis. For example, O'Rourke (1984; 1985) and Collete and Wall have evaluated selected vegetable crops on the basis of criteria such as average price over the production season, variability in weekly prices, and sensitivity of net income to yield reductions. While these analyses provide insight into the potential of one crop relative to another, they generally do not consider marketing, production, and price risks or profit components associated with multiple-crop rotations used in vegetable production.

While a crop may appear to have a high degree of market potential when evaluated on the basis of "market window" criteria, that crop may show reduced potential when the constraints present within a rotational system are considered. In other cases, a crop may not show individual potential, but it could be a valuable component of a rotational plan. For example, okra should be evaluated not as a single crop alternative but rather as an alternative within a multiple-crop system. In a recent article, Musser et. al. developed a rotational model for vegetable crop production, with the objective of profit maximization. While the Musser et al. article addressed the need for evaluation of vegetable crops within a rotational system, inherent risk and marketing constraints were not incorporated into this model.

OBJECTIVES

The overall objective of the research reported in this article was to analyze the potential profitability of vegetable crop production for farmers in the northern region of Alabama. Emphasis was given to possibilities for multiple-cropping rotational alternatives. Specifically, this analysis was developed to determine, from among vegetable crops that could be produced in the Sand Mountain and Tennessee Valley regions of Alabama, the alternatives and associated rotations which ex-

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hibited the greatest profit potential in light of marketing and price risk constraints.

While the risk associated with yield variability is recognized, this paper abstracts from production risk in an effort to concentrate on marketing and price-related risk aspects. This approach is admittedly incomplete, but the level of complexity necessary to realistically accommodate the numerous states of nature possible over the study period was not within the scope of the initial analysis reported in this paper. Production risk associated with seasonal and yearly variability in climatic conditions and the resultant reaction by a producer to such factors could not be adequately evaluated through yield sensitivity analysis. More sophisticated modeling with probabilistic functions would likely be needed.

While the study region is confined to north Alabama, the results have implications for other southeastern producing regions with similar marketing periods and costs. Also, the logic used in constructing the programming model may be used to evaluate similar decision problems for other geographic areas.

METHODS

A mixed integer linear programming model was developed to simulate the decision environment faced by an entry-level vegetable producer contemplating production for wholesale market level sales. The model included activities which permitted consideration of 13 vegetable crops within a three season (spring, summer, and fall) rotational system. The model was constructed so that crop rotations were permitted within given bounds established by marketing, rotational, and price risk constraints.

Typically, entry level producers in the region incorporate a limited number of acres, approximately 25 to 30, into an existing traditional production unit. Thus, this analysis addresses issues pertaining to production of 30 acres of vegetable crops. Given the large number of enterprise combinations currently existing on farms in the study region, a typical farm is difficult to define. Because of this, the analysis in this study ignores traditional row crop and livestock activities and focuses attention only on the components of the vegetable crop portion of such a farm. Further, it was assumed that potential producers have recognized and researched issues concerning the availability of harvesting, packing, and production labor as these factors pertain to their specific farm situations.

Production and Cost Data

Production levels and practices were estimated using enterprise budgets developed for Alabama and other southeastern states which exhibited production conditions representative of those observed in the study area. (Zwingli et al. contains a complete set of budgets which served as the basis for costs and returns used in this analysis.) The estimates were then adjusted following the advice of persons knowledgeable about vegetable production in the region. All pre- and post-harvest labor and production costs were specific to the study area. Machinery and irrigation expenses were included in production cost estimates. Higher production cost during the fall production season was represented by a 10-percent increase in the cost of chemical applications over that used during the spring and summer seasons. The effect of fertilizer carry-over from one period to another was not incorporated into the analysis due to the lack of adequate data. Production levels and costs represented an average of what a producer would expect using irrigation, following recommended production practices, and making good management decisions (Zwingli).

Transportation costs were based on a 40,000-pound load being transported from the study area to the selected markets at an average cost of $1.40 per loaded mile. The commercial truck rate was obtained by the Tennessee Valley Authority through a personal interview with a commercial carrier based out of Knoxville, Tennessee, and represented an average rate during the peak season with no back haul.

Price Data and Income Estimation

Market potential was evaluated for the period 1979–1983 at the Atlanta and Cincinnati wholesale produce markets, which represented the southeastern and midwestern regions, respectively (USDA, a and b). Prices received by producers were estimated by reducing wholesale prices by a 20-percent marketing margin. The marketing margin was estimated through personal interviews with marketing brokers and industry experts. Generally, prices of the selected vegetables were those received by southeastern producers. However, summer prices at the Cincinnati market represented those received by growers in the midwest production region.

Broccoli prices are reported by USDA and other agencies for California production. Due to the domination of California producers in the broccoli market and their high transportation costs, California prices tended to be higher than those that could be reasonably expected by Alabama producers. Alabama wholesale prices were estimated by reducing the reported California wholesale price for broccoli by 30 percent, which represented the difference between California FOB and the wholesale price.

Prices used for this study were those received for U.S. #1 produce. It was assumed that 25 percent of the harvest of cucumbers, okra, yellow and zucchini squash, and bell peppers would be below U.S. #1 standards and would receive a price equal to 60 percent of that received for U.S. #1 produce. These estimates of marketing quality and price were based upon information obtained from persons knowledgeable in vegetable crop production and marketing.

Net income for a given rotation was a simple sum of net incomes for each of the crops in the rotation. Net incomes represented returns to owners' land, labor, and management.

Marketing Constraints

In general, wholesale brokers are more receptive to producers who can provide an adequate supply of a given crop for as long a period of time as possible. Thus, it was assumed that if producers are to access wholesale markets, they must supply a sufficient quantity of a given crop over a sufficient period of time. Necessary supply requirements are dictated by the market characteristics of a specific crop, and, as such, sufficient quantities and supply period lengths may vary between both crops and markets.

To accommodate these market requirements, each crop activity consisted of more than one planting date, thereby extending the harvest period past one that would result from a single planting. While planting dates are representative of those seen during most years, it should be noted that planting and harvest dates are a function of a number of biological and climatic factors and, therefore, may vary from year to year. Designated pro-

TABLE 1. CROP ACTIVITIES, ACREAGES, AND PLANTING AND ASSOCIATED HARVEST PERIODS FOR SELECTED VEGETABLE CROPS, SAND MOUNTAIN AND TENNESSEE VALLEY REGIONS OF ALABAMA

Vegetable crop[b]	Planting period	Harvest period	Prescribed minimum requirement
	——— - Weeks[a] - ————		Acres
Snap beans:			
Bn1a	14, 16	21–25	25.00
Bn1b	14, 16	21–25	30.00
Bn2a	32, 33	40–43	25.00
Bn2b	32, 33	40–43	30.00
Broccoli:			
Br1	9, 10	16–19	15.00
Br2	32, 33	40–43	15.00
Br3	33, 34	42–45	15.00
Cabbage:			
Cb1	8–10	17–20	15.00
Cb2	9–11	18–21	15.00
Cb3	10–12	19–22	15.00
Cb4	11–13	20–23	15.00
Cb5	32–35	42–45	15.00
Yellow sweet corn:			
Cn1ay	11–18	22–29	21.25
Cn1by	11–18	22–29	25.50
Cn1ey	11–18	22–29	30.00
White sweet corn:			
Cn1aw	11–18	22–29	3.75
Cn1bw	11–18	22–29	4.50
Collards:			
Cl1	7	17–25	5.00
.	.	.	.
.	.	.	.
.	.	.	.
Cl26	32	42–50	5.00

Continued

TABLE 1. CONTINUED

Vegetable crop[b]	Planting period	Harvest period	Prescribed minimum requirement
	— — — — Weeks[a] — — — —		Acres
Cucumbers:			
Cu1a	15, 17	24–28	25.00
Cu1b	15, 17	24–28	30.00
Cu2a	29, 31	37–41	25.00
Cu2b	29, 31	37–41	30.00
Cu3a	30, 32	38–42	25.00
Cu3b	30, 32	38–42	30.00
Cu4a	31, 33	39–43	25.00
Cu4b	31, 33	39–43	30.00
Okra:			
Ok1a	18	26–39	25.00
Ok1b	18	26–39	30.00
Ok2a	19	27–40	25.00
Ok2b	19	27–40	30.00
Bell peppers:			
Pb1a	16	27–39	25.00
Pb1b	16	27–39	30.00
. . .	. . .	. . .	. . .
Pb6a	21	32–39	25.00
Pb6b	21	32–39	30.00
Yellow squash:			
Sq1a	16, 18	23–27	17.00
Sq1b	16, 18	23–27	20.00
Sq1c	16, 18	23–27	25.00
Sq1d	16, 18	23–27	30.00
. . .	. . .	. . .	. . .
Sq16a	31, 33	38–42	17.00
Sq16b	31, 33	38–42	20.00
Sq16c	31, 33	38–42	25.00
Sq16d	31, 33	38–42	30.00
Zucchini squash:			
Zu1a	16, 18	22–26	8.00
Zu1b	16, 18	22–26	10.00
. . .	. . .	. . .	. . .
Zu16a	31, 33	37–41	8.00
Zu16b	31, 33	37–41	10.00
Turnip greens:			
Tu1	9	14–17	5.00
. . .	. . .	. . .	. . .
Tu7	15	20–23	5.00
Tu8	31	36–40	5.00
. . .	. . .	. . .	. . .
Tu13	36	41–45	5.00
Watermelons:			
Wm1	18	29, 30	2.50
Wm2	19	30, 31	2.50

[a] Week numbers represent chronological weeks throughout the year. For example, Week 1 represents January 1–7, Week 18 represents April 30–May 6, Week 50 represents December 10–16, etc.

[b] Vegetable crop designations refer to enterprise (Bn, Pb, Zu, etc.) planting (1, 2, 3, etc.), prescribed acreage (a, b, c, etc.) and yellow (y) or white (w) sweet corn. For example, Bn1a refers to the first planting of snapbeans with a prescribed acreage of 25, while Cn1ay represents the first planting of yellow sweet corn with a prescribed acreage of 21.25 which allows consideration of 4.5 acres of white sweet corn and 5 acres of watermelons.

duction levels for crops were determined using the criterion that if a crop were produced, production had to equal at least one tractor trailer load of that given commodity per week. The designated acreage levels necessary for meeting this constraint varied among crops.

All crop production alternatives considered are listed in Table 1, along with planting and harvest weeks and acreage levels. As an example, the first planting of snap beans (Bn1a) was seeded in week 14 (April 8). Seeding was completed in week 16 (April 22). Harvest extended over a five-week period from weeks 21 to 25 (May 27 to June 24). If the snap bean activity came into solution, it did so at a 25-acre level, thereby meeting the truck load requirement.

Other constraints based on marketing considerations were incorporated into the model. White sweet corn comprises approximately 15 percent of the total demand for all sweet corn (yellow and white varieties), with producers in the study region producing both varieties and shipping in mixed loads or growing and shipping yellow varieties alone (Zwingli). To be consistent with current practices in the study region, it was assumed that if white sweet corn were produced, it would occupy 15 percent of the total acreage of both varieties. Yellow sweet corn was allowed to be produced exclusive of white sweet corn.

Given the more restricted market for zucchini squash as compared to yellow squash, producers often either produce both varieties and ship in mixed loads or produce only yellow squash. For this reason, it was assumed that zucchini squash, if feasible, would occupy one-third of the total acreage produced of both varieties. Yellow squash was allowed to be produced independent of zucchini squash.

Additional constraints were used to regulate the supply levels of other selected crops. Much interest has been shown in broccoli production in north Alabama. This interest stems from the increased demand for broccoli and its production similarities with cabbage which has traditionally been grown in the region. While potential is indicated, to date only preliminary information on production practices and recommended broccoli varieties is available. A priori knowledge concerning the high income potential and low price variability of broccoli showed that it would come into solution at a maximum level (30 acres) if allowed. Given this fact and the newness of production in this region, broccoli plantings were restricted to a 15-acre level, thereby allowing for the possibility of other vegetable crops to be produced with broccoli.

Bell peppers, cucumbers, okra, yellow squash, and yellow-zucchini squash production activities were allowed to enter solution at either 25- or 30-acre levels. Two acreage levels were used to allow a total of five acres of watermelons to come into solution in conjunction with another late spring-summer crop. This accommodation was made because of the relative importance of watermelon production in Alabama and because many producers in the region consider the planting of a limited acreage of this crop. Watermelon plantings were limited to two 2.5-acre plantings. Most greens sold at the wholesale or terminal market level are produced by growers with large operations providing a variety of greens, such as turnip greens, kale, mustard, and collards, during all three growing seasons. While production of turnip greens during the spring and spring and fall seasons may provide some potential in mixed load type sales, wholesale buyers may be reluctant to establish a relationship with a producer who cannot supply greens such as collards, which demonstrate low income potential, during the interim. For this reason and given the limited demand for greens, two models were specified, the first allowing the production of turnip greens and collards and the second excluding their production.

Crop Rotation

Crop rotations are an effective means for minimizing yield losses that result from a large variety of insects and diseases which plague vegetable crops. Crops within the same family were assumed not to be produced successively on a given acre of land during a crop year. To accommodate this production restriction, a constraint row for each crop family was used which limited the total number of acres that could be planted within a given family during a crop year to be less than or equal to the available land (30 acres). Three rotational constraints were employed to represent the legume (snap bean), cruficer (broccoli and cabbage), and cucurbit (cucumber, yellow and zucchini squash, and watermelon) families. While belonging to the crucifer family, turnip greens and collards were allowed to come into solution both before and after broccoli and cabbage. This concession was made because of the importance turnip greens and collards hold in the limited number of triple-crop rotations feasible in the study area. Also, this assumption is consistent with production decisions currently being made in the study region.

While detrimental insects and diseases affect more than one family of vegetable crops, the most problematic consequences are evidenced when like vegetable families are planted in sequence on the same land. As such, no additional constraints were needed for okra, sweet corn, or bell peppers. While this rotational system is less sophisticated than that presented by Musser et al., it more easily accommodated the large number of crop activities used in this model and effectively controlled rotations as desired.

The Programming Model

A Target MOTAD analysis, as developed by Tauer, was utilized so that the risk associated with price-related income variability could be incorporated into the previously mentioned mixed-integer programming model. While alternative risk analysis procedures such as MOTAD and quadratic programming were available, Target MOTAD was chosen because of the ease of implementation and because the designation of target incomes serves to simulate the way that many farmers make their production decisions.

In the context of this model, the Target MOTAD methodology allowed for maximization of net income obtainable on 30 acres subject to the minimization of negative deviations in net income below a specified target income level. Because most producers are concerned with deviations in income below an expected level, as addressed by a Target MOTAD methodology, and not with absolute deviation about the mean income level, as addressed by a MOTAD analysis, Target MOTAD was deemed more appropriate for this analysis. The abbreviated matrix given in Table 2 illustrates the basic logic that was followed in model construction.

RESULTS

Analysis for two potential terminal markets, Atlanta and Cincinnati, are presented in the following discussion. With the objective of the research being to evaluate the profitability of vegetable crop production in the northern area of Alabama, consideration of these markets would be appropriate.

Atlanta Market

As evidenced by the results presented in Table 3, profit from vegetables sold in the Atlanta market was maximized ($77,524) using a triple-crop rotation with broccoli (15 acres) and turnip greens (15 acres) grown in both the spring and fall seasons and with zucchini (8 acres) and yellow squash (20 acres) produced during the late spring-summer season. As acceptable deviations in net income and target levels were reduced, only slight changes in planting and harvest dates for the four crops included in the rotations were evi-

TABLE 2. ILLUSTRATION OF MIXED-INTEGER TARGET MOTAD PROGRAMMING MATRIX

	Decision Variables										
Item[a]	VC1	VC2	VC3	VC4	VC5	D1	D2	D3	D4	D5	Constraint Values
RETURN	ANR1	ANR2	ANR3	ANR4	ANR5						
YEAR 1	NR11	NR21	NR31	NR41	NR51	1					≥ T
YEAR 2	NR12	NR22	NR32	NR42	NR52		1				≥ T
YEAR 3	NR13	NR23	NR33	NR43	NR53			1			≥ T
YEAR 4	NR14	NR24	NR34	NR44	NR54				1		≥ T
YEAR 5	NR15	NR25	NR35	NR45	NR55					1	≥ T
DEV						1	1	1	1	1	≤ TD
LA7	AC17	AC27	AC37	AC47	AC57						≤ L
LA8	AC18	AC28	AC38	AC48	AC58						≤ L
LA9	AC19	AC29	AC39	AC49	AC59						≤ L
LA10	AC110	AC210	AC310	AC410	AC510						≤ L
LA11	AC111	AC211	AC311	AC411	AC511						≤ L
.	.	.	.	.	.						
.	.	.	.	.	.						
.	.	.	.	.	.						
LA50	AC150	AC250	AC350	AC450	AC550						≤ L

[a] Alphabetic characters represent coefficients used in the anaysis. ANR is the average net return for each vegetable crop; NR is the net return for each vegetable crop for each year that information was available; T is the target net income level; D is the amount of negative deviation allowed from target levels; L is the total amount of land available; TD is the maximum deviation from target levels that is permitted; LA is the land available each week, and VC is each vegetable crop.

TABLE 3. PROFIT-MAXIMIZING VEGETABLE CROP ROTATIONS AT ALTERNATIVE TARGET INCOME AND DEVIATION LEVELS, WITH AND WITHOUT PRODUCTION OF COLLARDS AND TURNIP GREENS, ATLANTA MARKET AND 30 ACRES OF LAND, FOR THE SAND MOUNTAIN AND TENNESSEE VALLEY REGIONS OF ALABAMA

Mean income ($)	Negative deviations from target income ($)	Activities by Season[a]		
		Spring	Summer	Fall
Production of collards and turnip greens permitted:				
Target income = $65,000:				
77,524	11,390	Br1, Tu2-Tu4	Sq6b, Zu6a	Br3, Tu9-Tu11
76,908	10,246	Br1, Tu1-Tu3	Sq5b, Zu5a	Br2, Tu8-Tu10
76,456	10,152	Br1, Tu1-Tu3	Sq5b, Zu5a	Br2, Tu8, Tu9, Tu11
74,781	9,964	Br1, Tu1-Tu3	Sq5b, Zu5a	Br2, Tu8, Tu10, Tu11
Target income = $60,000:				
77,524	6,390	Br1, Tu2-Tu4	Sq6b, Zu6a	Br3, Tu9-Tu11
76,908	5,246	Br1, Tu1-Tu3	Sq5b, Zu5a	Br2, Tu8-Tu10
76,456	5,152	Br1, Tu1-Tu3	Sq5b, Zu5a	Br2, Tu8, Tu9, Tu11
74,781	4,964	Br1, Tu1-Tu3	Sq5b, Zu5a	Br2, Tu8, Tu10, Tu11
Target income = $55,000:				
77,524	1,390	Br1, Tu2-Tu4	Sq6b, Zu6a	Br3, Tu9-Tu11
76,908	246	Br1, Tu1-Tu3	Sq5b, Zu5a	Br2, Tu8-Tu10
76,456	152	Br1, Tu1-Tu3	Sq5b, Zu5a	Br2, Tu8, Tu9, Tu11
76,192	58	Br1, Tu1-Tu3	Sq5b, Zu5a	Br2, Tu10, Tu11, Tu12
Production of collards and turnip greens not permitted:				
Target income = $45,000:				
56,039	22,320	Br1, Cb4	—	Bn2b
Target income - $40,000:				
56,039	12,320	Br1, Cb4	—	Bn2b
Target income = $35,000:				
56,039	6,438	Br1, Cb4	—	Bn2b
Target income = $30,000:				
56,039	1,438	Br1, Cb4	—	Bn2b

[a] See Table 1 for definitions of activities.

denced along with minor reductions in average net income. Full utilization of land was realized with all solutions.

When greens were excluded from the analysis, a double-crop rotation comprised of 15 acres each of spring broccoli and cabbage followed by 30 acres of fall snap beans came into the solution (Table 3). This rotation was stable across all designated target levels, with profit decreasing from $77,524 to $56,039 when greens production was not considered. A higher degree of income variability, indicated by the magnitude of the income deviations at alternative target income levels, was realized when greens were a feasible production alternative.

With the non-greens solution, land was not fully utilized. Thirty acres of land were idle during weeks 21 to 31 (May 27–August 11). The inclusion of spring cabbage in the solution precluded any triple-crop rotations. This would be true even if cabbage were to be planted at the earliest date (week 8). This result indicates that acres of cabbage returned a higher net income, with less than or equal negative deviation from the selected target income levels, than any alternative crop which could be accommodated in a triple-crop rotation.

When spring cabbage was included in the rotation, income increased. This is in agreement with results derived by Zwingli which indicated that while cabbage showed lower than average returns during most years, much greater income may be realized in a given year. Examination of the average annual price for cabbage indicated that cabbage transplanted on weeks 9 (March 4) and 11 (March 18) and harvested on weeks 20 (May 20) through 23 (June 10) received an average price of $12.63 per 50-lb. carton in year 1982, in contrast to an average price of $3.94, $5.22, $4.00, and $6.44 in years 1979, 1980, 1981, and 1983, respectively. As such, the higher than average prices seen in 1982 "pulled" the average net income up, thereby resulting in spring cabbage possessing a favorable trade-off between profitability and negative deviation from the selected target income levels when evaluated over five years. It should be noted that while a high degree of income variability existed, as indicated by the yearly variation in average price, Target MOTAD minimizes only negative deviation in income below the specified target level, so the high positive value for cabbage did not influence the measure of deviation.

Cincinnati Market

Data presented in Table 4 show that three triple-crop rotations came into solution at various target income and acceptable deviation levels. At the $65,000 target level, income was maximized at $76,052 using a rotation consisting of 15 acres each of both spring and fall broccoli and turnip greens in conjunction with 25 acres of summer squash and 5 acres of watermelons. As acceptable deviation below the $65,000 target level was reduced from $17,907 to $17,746, yellow squash and watermelons were replaced by 20 acres of yellow squash and 10 acres of zucchini squash. The third rotation optimized at the $55,000 target level with $6,758 of negative deviation and consisted of 15 acres each of spring broccoli and turnip greens, 25 acres of yellow squash and 5 acres of watermelons in the summer, and 30 acres of fall snap beans. All three rotations indicated approximately equal levels of income, but differing degrees of risk, as measured by negative deviations below the target. Net incomes

TABLE 4. PROFIT-MAXIMIZING VEGETABLE CROP ROTATIONS AT ALTERNATIVE TARGET INCOME AND DEVIATION LEVELS, WITH AND WITHOUT PRODUCTION OF COLLARDS AND TURNIP GREENS, CINCINNATI MARKET AND 30 ACRES OF LAND, FOR THE SAND MOUNTAIN AND TENNESSEE VALLEY REGIONS OF ALABAMA

Mean income ($)	Negative deviations from target income ($)	Activities by Season[a] Spring	Summer	Fall
Production of collards and turnip greens permitted:				
Target income = $65,000:				
76,052	17,907	Br1, Tu1-Tu3	Sq5c, Wm1, Wm2	Br2, Tu9-Tu11
75,679	17,746	Br1, Tu1-Tu3	Sq5b, Zu5b	Br2, Tu8-Tu10
Target income = $60,000:				
76,052	12,907	Br1, Tu1-Tu3	Sq5c, Wm1, Wm2	Br2, Tu9-Tu11
75,679	12,746	Br1, Tu1-Tu3	Sq5b, Zu5b	Br2, Tu8-Tu10
Target income = $55,000:				
76,052	7,907	Br1, Tu1-Tu3	Sq5c, Wm1, Wm2	Br2, Tu9-Tu11
75,679	7,746	Br1, Tu1-Tu3	Sq5b, Zu5b	Br2, Tu8-Tu10
75,457	7,587	Br1, Tu1-Tu3	Sq5c, Wm1, Wm2	Br2, Tu9, Tu10, Tu13
74,731	6,758	Br1, Tu1-Tu3	Sq5c, Wm1, Wm2	Bn26
Production of collards and turnip greens not permitted:				
Target income = $65,000:				
71,123	21,995	Br1, Cb4	—	Sq15d
69,825	21,354	Br1, Cb4	—	Sq15b, Zu15b
66,143	20,365	Br1, Cb4	—	Sq15d
64,844	19,723	Br1, Cb1	—	Sq15b, Zu15b
Target income - $60,000:				
71,123	11,996	Br1, Cb4	—	Sq15d
69,825	11,354	Br1, Cb4	—	Sq15b, Zu15b
66,143	10,365	Br1, Cb1	—	Sq15d
64,844	9,723	Br1, Cb1	—	Sq15b, Zu15b
Target income = $55,000:				
71,123	2,298	Br1, Cb4	—	Sq15d
69,825	1,354	Br1, Cb4	—	Sq15b, Zu15b
66,143	1,982	Br1, Cb1	—	Sq15d
64,844	1,866	Br1, Cb1	—	Sq15b, Zu15b

[a] See Table 1 for definitions of activities.

TABLE 5. SUMMARY OF CROPS WHICH CAME INTO FEASIBLE CROP ROTATIONS WITH AND WITHOUT PRODUCTION OF COLLARDS AND TURNIP GREENS, ATLANTA AND CINCINNATI MARKETS AND 30 ACRES OF LAND, SAND MOUNTAIN AND TENNESSEE VALLEY REGIONS OF ALABAMA

	Season and crop		
Market	**Spring**	**Summer**	**Fall**
Production of collards and turnip greens permitted:			
Atlanta	Broccoli Turnip Greens	Yellow Squash Zucchini Squash	Broccoli Turnip Greens
Cincinnati	Broccoli Turnip Greens	Yellow Squash Zucchini Squash Watermelons	Broccoli Turnip Greens
Production of collards and turnip greens not permitted:			
Atlanta	Broccoli Cabbage	—	Snap Beans
Cincinnati	Broccoli Cabbage	—	Yellow Squash Zucchini Squash

in the Cincinnati market were approximately equal to those seen in the Atlanta market.

The non-greens solution for the Cincinnati market was similar to that indicated for the Atlanta market with 15 acres of both broccoli and cabbage produced in the spring (Table 4). Unlike the Atlanta solution, where snap beans occupied the fall season, yellow and zucchini squash showed the greatest potential during the fall in the Cincinnati market. Yellow squash (30 acres) and yellow-zucchini combination (20 and 30 acres, respectively) occupied the fall season on an alternating basis as target income and negative deviation levels were reduced.

Average net income was reduced only slightly (from $76,052 to $71,123) when the optimal solutions with and without turnip greens and collards were compared in the Cincinnati market. Solutions for Cincinnati demonstrated higher income potential and resulted in a lower degree of income risk than was seen in the Atlanta market. As in the Atlanta market, cabbage precluded any triple-crop rotation from coming into solution. Average prices received for cabbage sold in the Cincinnati market for the years 1979 through 1983 were $5.58, $6.63, $5.78, $14.50, and $7.84 per 50 lb., respectively.

SUMMARY

Results of this analysis indicate that rotations were generally stable with respect to markets and relative to crop mixes as target income levels and acceptable negative deviation levels were varied. While some trade-offs between average net income and risk associated with negative deviation in net income below the target resulted in crops changing from one rotation to another in the Cincinnati market, most trade-offs included a shifting of planting and hence harvest dates.

Results are summarized for both models (with and without greens production) in Table 5. As shown, spring and fall broccoli and turnip greens and late spring-summer yellow and zucchini squash were the dominant crops seen in the triple-crop rotations. The results also indicated that a favorable watermelon market existed for Cincinnati, with five acres being produced in combination with yellow squash during the late spring-summer season.

When greens production was eliminated from consideration, a double-crop rotation was optimal in both the Atlanta and Cincinnati markets (Table 5). In both markets, broccoli and cabbage were the dominant spring crops with snap beans and yellow and zucchini squash present during the fall. The analysis also pointed out that early plantings in the spring and late plantings in the fall were more profitable and price stable.

As indicated in Zwingli, crops such as bell peppers, while showing moderate income potential, had a high degree of price and hence income variability. Collards, on the other hand, had low variability in price and low income potential. Sweet corn had low income potential and a high degree of price variability, while okra showed moderate income potential and price variability.

CONCLUSIONS AND IMPLICATIONS FOR FUTURE RESEARCH

In part, the stability shown by the feasible rotations may have been a direct function of the rigidities built into the model through the use of prescribed acreage levels. Pre-tests of the model, allowing for continuous acreage levels, resulted in rotations containing a wide range of crops generally being produced at levels far below sufficient quantities necessary to gain access to wholesale or terminal markets. As such, use of discrete acreage levels, dictating sufficient production levels, appears to be appropriate for this type of analysis.

As stated earlier, production risk, while important, is inadequately measured by a simple sensitivity analysis on yield levels. Simply reducing the yield level below that on average which could be expected by a good producer would in effect imply a reduction across all production seasons and years. Thus, one would not truly be measuring the effects of detrimental climatic conditions such as early spring or late fall frosts which vary from year to year. If these effects were to be realistically assessed, actual historic weather data for the study region and time period would have to be incorporated into the model, along with appropriate adjustments for planting dates and yield reductions resulting from adverse weather patterns.

An argument might also be made for the exclusion of production risk from such models based on the actual planning practices of vegetable crop producers. Many producers base what-to-grow and when-to-plant decisions on perceived profit potential and traditional production patterns. Then, after viewing the success or failure of other producers, they adjust practices to meet resource constraints. In many cases, producers seem willing to assume the risk of an early spring or late fall crop planting in expectation of "hitting" a good market.

The direct effect of the exclusion of production risk is evidenced by the high net income shown for all the feasible rotations. Income levels were further enhanced under the assumption that producers are able to find buyers for all their produce over the entire study period. Therefore, results from this analysis should be viewed in light of the often large barriers which exist to wholesale market entrance. Inexperienced producers who are outside traditional production areas may often be unable to locate buyers for their produce at the wholesale market level. If a producer resorts to an alternative local market, where conditions of low prices and limited volume sales often exist, or is unable to find a buyer at any market level, large net losses may be realized. It should also be noted that levels of negative deviation below prescribed targets would increase as net income levels are reduced. Price risk would then be greater than indicated in this study.

No restrictions were placed in the model relative to labor requirements and associated availability. Given the size of the vegetable crop enterprise (30 acres) and the fact that harvesting and packing labor are currently available in the study region, such an assumption can be justified. As the size of the enterprise being examined increases, the need for inclusion of labor and especially management constraints associated with production and marketing activities becomes important.

Also, as the number of acres available for vegetable production increases, the assumptions concerning marketing activities should be changed. For example, if the available acreage used in this analysis were to be increased, the marketing period which allowed for the idle land in the non-greens solution for the Atlanta market should be changed (Table 3). Because land was limited to 30 acres, the length of the supply period for snap beans was constrained to five weeks. As acreage is increased, it would become feasible and advisable to supply snap beans, or an alternative crop, for as long a period as possible.

In conclusion, it is evident that many of the difficulties in analyses such as these are a direct result of the lack of good and timely data on such factors as yields, production costs, effects of changes in weather patterns, labor, and especially management requirements. Given the availability of such data, analyses such as these could be validated. Also, evaluation of periods longer than the five years used in this study would tend to reduce or average-out income levels dramatically inflated by one exceptionally good year, as evidenced for cabbage in 1982. The need for continued research and data collection is necessary if the market potential for vegetable crops is to be realistically evaluated.

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