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RISK AND SUSTAINABLE AGRICULTURE: A TARGET-MOTAD ANALYSIS OF THE 92-YEAR "OLD ROTATION"

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Abstract

Target-MOTAD was used to assess the risks and returns of sustainable cotton crop rotations from Auburn University's 92-year "Old Rotation." Study results analyze rotations of continuous cotton, with and without winter legumes; two years of cotton-winter legumes-corn, with and without nitrogen fertilization; and three years of cotton-winter legumes-corn and rye-soybeans double-cropped. Ten years of observations on deviations from target income were used to identify optimal sustainable rotation(s). Study results suggest that diversification in rotations, as well as in crops, results in the least risk for a given level of target income.

Key words: Target-MOTAD, risk-returns, cotton rotation(s), sustainable agriculture.

Recent concern about low-input sustainable agriculture has renewed interest in the "Old Rotation" experiment at Auburn University, Alabama. Over its 92-year history, data have been collected from the "Old Rotation" on the effect of alternative rotation schemes on sustainable cotton-based production systems (Mitchell). In particular, the effect of winter legumes as a source of green manure and nitrogen has been analyzed for the crops included in the rotations. Although the "Old Rotation" has had a long history of agronomic interpretation, no work has been done on the economic implications of this study. In addition, conditions in agriculture call for farm decision makers to formulate and implement optimal farm plans in an increasingly risky environment. An implication of current conditions for sustainable farm plans is that optimal solutions should provide the minimum possible risk for an acceptable level of return. Motivated by this implication, this study used a Target-MOTAD analysis to focus on the "Old-Rotation." The primary purpose of this paper was to determine the risk-minimizing sustainable rotation scheme(s) that would optimize expected returns for a typical central and southern Alabama farm operation.

BACKGROUND

Over its history, agronomic insights regarding nitrogen availability have been gained from the six rotation schemes of the "Old Rotation." These insights can be summarized as follows.

(1) Average cotton lint yields increased from 214 pounds to 605 pounds per acre when winter legumes were added to a continuous cotton cropping system with no legume or fertilizer nitrogen (N). Fertilizer and legume N had about equal effects on cotton yields in the continuous cotton rotations, producing 624 versus 605 pounds of lint, respectively.

(2) A two-year cotton-legume-corn rotation increased cotton yields by about 11 percent over continuous cotton grown with legumes alone.

(3) A three-year rotation of cotton, legumes, corn, rye/soybeans double-cropped, but with no N fertilizer, produced about the same yield of cotton (744 lbs./acre) as a two-year rotation of cotton-legumes-corn (753 lbs./acre) with N fertilizer. However, the three-year rotation had higher corn yields (62 versus 50 bu./acre).

(4) Corn grown under all rotation schemes, planted in late April and not irrigated, had consistently low yields (40 to 62 bu./acre).

(5) Soybeans produced consistently high yields, averaging 37 bushels per acre when double-cropped with rye (27 bu./acre).

Approximately 40 percent of the state's cotton crop is produced in central and southern Alabama (Alabama Agricultural Statistics). Average size of the farms used in this analysis is 570 acres, of which an average of 340 acres is devoted to cotton (Young).

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The implications of the establishment of winter legumes in a continuous cotton rotation pertain primarily to central and southern Alabama, where climatic conditions make this possible. These regions are similar to comparable climatic regions in Louisiana, Mississippi, Georgia, and Florida. The implications of the study should therefore be relevant to these states as well as to Alabama.

Although no formal survey data exist, extension service and experiment station personnel in the central and southern part of Alabama estimate that 70 to 85 percent of the producers use a continuous cotton rotation with chemical nitrogen fertilizer. Less than 30 percent of the producers use a winter cover crop within a continuous cotton rotation. The continuous cotton-fallow rotation persists as the predominant practice throughout the state despite studies that show a yield advantage to multiple-year rotations with other crops and winter legumes (Burmester *et al.*; Mitchell). The reason given for this is that farmers seem to prefer short-run reductions in net income risk over longer-run increases in risk associated with losses of organic matter and soil erosion.

SUSTAINABLE AGRICULTURE

Several alternative definitions of sustainable agriculture exist. However, all seem to agree that the definition includes reductions in the reliance on nonrenewable inputs, such as petroleum-based fertilizer and pesticide products; reductions in reliance on externally produced inputs; reductions in environmental degradation; and an increase in management input (Dover and Talbot; Fisher; Granatstein; Poincelot). Fisher and Poincelot also add that the definition must be dynamic enough to include future changes in biological systems.

As part of the sustainable agriculture literature, Granatstein offered legumes in crop rotations as a renewable source of nitrogen. Poincelot pointed out the value of legume forages and cover crops in rotations to provide organic matter as well as nitrogen to the soil and thus to act as an aid in reducing soil erosion. Heichel cited the role of legumes in reducing the fossil fuel energy required in alternative Minnesota corn rotations, as measured by daily "fossil energy flux." In terms of the reduction in variability due to legumes, he stated, "Compared with continuous cropping, the fossil energy flux in rotations is reduced as much as 45 percent. Crop yields (dry matter basis) are often maintained within a range of plus or minus 10 percent of the mean over the duration of the rotation." The role of legumes in the "Old Rotation" is thus defined to be part of the "sustainable" agricultural research.

RISK EFFICIENCY IN FARM PLANS

Risk efficiency in farm planning has received a great deal of treatment in the economics literature. Risk analysis as applied to crop rotations, especially as applied to sustainable agriculture, has not been widely discussed.

Brown used stochastic dominance to define risk efficient sets of alternative wheat, canola, and lentil rotations in order to describe more effectively Saskatchewan producer behavior with respect to actual rotation choices. He stated the case for using stochastic dominance over alternative methods for selecting the most risk-efficient rotation. Zacharias and Grube used stochastic dominance to evaluate the effect of weed control and alternative crop rotations on distributions of net returns in Illinois. They explicitly stated that the alternative weed control-crop rotations are discrete systems. Neither study addressed the inability of the stochastic dominance method to select combinations (out of the infinite permutations) of the modeled systems as the optimal risk-efficient set of rotations.

Crisostomo *et al.* analyzed six alternative double-crop rotations in southeast Kansas using Target-MOTAD. Their results demonstrated that a combination of two alternative rotations can be the outcome of an optimal (risk efficient) farm plan for a given level of target income.

King and Robison have discussed the operational difficulties with the practical applications of expected utility and other decision models dependent upon the estimation of risk aversion coefficients.

With these background studies as a basis, it was concluded that Target-MOTAD was the method of choice for optimizing the risk-efficient solutions for the "Old Rotation." Target-MOTAD was used to develop a frontier of optimal rotation schemes, subject to the limitations imposed on the feasible solutions by the alternative levels of risk and target income (McCamley and Kliebenstein).

METHOD

Target-MOTAD is an extension of MOTAD that is used to determine the set of feasible risk-minimizing crop rotations from the possible set of profitable "Old Rotation" alternatives (Tauer; Hazell). Target-MOTAD was chosen over other possible methods because of its practical and theoretical appeal and because of the ability to examine optimal combinations of rotations. As demonstrated by Tauer, Target-MOTAD results are second-degree stochastic dominant to solutions provided by MOTAD.

The Target-MOTAD model can be formulated as:

$$(1) \quad \text{Maximize E(Return)} = \sum_{j=1}^{n} C_j X_j$$

subject to

$$(2) \quad \sum_{j=1}^{n} A_{ij} X_j \leq B_i$$

$$(3) \quad T - \sum_{j=1}^{n} C_{tj} X_j - Y_t \leq 0$$

$$(4) \quad \sum_{t=1}^{s} P_t Y_t = G$$

$$(5) \quad G = M \text{ to } 0$$

$$(6) \quad i = 1,2,......, m$$

$$(7) \quad t = 1,2,......,s$$

$$(8) \quad X_j, Y_t, \geq 0,$$

where E(return) is the expected return from the optimal plan, C_j is the expected return from activity j, X_j is the level of activity j, A_{ij} is the technical requirement of activity j for resource i, B_i is the level of resource i, T is the target level of return, C_{tj} is the return of activity j for period t, Y_t is the deviation below T for time period t, P_t is the probability of the state of nature (Y_t) occurring at time t, G is a risk constant parameterized from M to 0, m is the number of resource constraint equations, s is the number of time periods or states of nature, and M begins as an arbitrary large number. Risk (G) is measured in dollars.

The model is set up to maximize expected return subject to achieving a satisfactory level of compliance with target income (T). A set of efficient farm plans is obtained by parameterizing the level of risk (G) from the arbitrarily large number (M) to 0 (equation 4). The resulting farm plans maximize expected returns for a given risk level, subject to the minimized negative deviations from T. Changes are made in the value of G and optimal solutions are obtained until all feasible possible changes in basis occur, and the value of expected net return cannot be improved by increasing the level of risk.

ESTIMATION CONSIDERATIONS

The "Old Rotation" experiment consists of 13 plots, 21.5 by 136.1 feet, that have been maintained in cotton-based rotations since 1896. In 1988, the site was listed on the National Register of Historical Places as the oldest continuous cotton study in the United States. The study has been revised several times since its inception; the last revision was in 1960 (Mitchell; Evans and Sturkie; Davis). Basic rotations included in the study are:

Continuous Cotton:

(1) With winter legumes; no nitrogen fertilizer (CtL),

(2) No winter legumes; no nitrogen fertilizer (Ct),

(3) No winter legumes; 120 pounds of nitrogen per acre (CtN).

Two-Years Cotton-Corn:

(4) With winter legumes; no nitrogen fertilizer (CtLCn),

(5) With winter legumes; 120 pounds of nitrogen per acre on each crop (CtLCnN).

Three-Years Cotton-Corn-Rye/Soybeans:

(6) Winter legumes after cotton; 60 pounds of nitrogen per acre on rye (CtLCnS).

The test was not designed as a statistically replicated study. However, there are multiple replications in the test due to the timing of the rotations and, originally, due to different scheduling of phosphorus and potassium fertilizer applications (Table 1). The timing of P and K fertilizer applications had an affect in the early days of the experiment but are no longer significant because of a buildup of these chemicals in the soil (Davis). Therefore, for the purpose of this study, only crop rotation effects are considered.

This study used 10 years of available crop year data (1978/79-1987/88) from the "Old Rotation" to analyze the profitability of six alternative rotation schemes (Table 1). Structural changes, due to changing hybrids, machinery, and pest control, are minimized by limiting data used to this time period.

Crop prices were estimated using the Alabama Agricultural Statistics estimates of annual cash prices and the USDA's Agricultural Outlook estimates of deficiency payments on farm program crops. Extension Service enterprise budgets were used to estimate variable costs and returns above variable costs for each of the alternative rotations. Prices and costs used in the analysis were indexed to the 1988 crop year.

The Universal Soil Loss Equation (USLE) (Wishmeir and Smith) was used to calculate potential annual soil losses from sheet and rill erosion under the six cropping systems used. The USLE estimates erosion losses based upon rainfall frequency, soil parameter, slope, length, cropping system, and conservation practice. The cropping system was the only factor that varied with the long-term experiment (Table 2). The soil at this test location is a clayey, kaolinitic, thermic Typic Hapludult on a 2 percent slope. Tolerable annual soil

Table 1. Average Yields Per Acre For Alternative Rotations Under The Old Rotation Study

	Period									
Crop	1	2	3	4	5	6	7	8	9	10
Cotton, No Nitrogen Fertilizer[a]										
Seed Cotton (lbs)	401	488	645	692	913	512	622	459	477	871
Cotton, Winter Legumes[b]										
Seed Cotton (lbs)	1730	1338	1424	2000	2637	1333	2799	1045	1090	1815
Cotton, Legumes-Corn[b]										
Seed Cotton (lbs)	1634	1402	1630	2102	2652	1685	2413	1329	1554	1670
Corn (bu)	15	41	13	40	79	27	17.5	2	69	48
Cotton, Legumes-120 Lbs. N on Corn[b]										
Seed Cotton (lbs)	1900	1661	1577	2500	2797	2016	3102	1292	2119	2105
Corn (bu)	38	45	27	45	90	28	18.1	16	76	65
Cotton, Legumes-Corn, 60 Lbs. N on Rye/Soybeans Double-Cropped[a]										
Seed Cotton (lbs)	1634	1730	2210	2371	2755	2030	2530	1206	1608	1670
Corn (bu)	46	57	31	30	92	36	51	9	111	58
Rye (bu)	21	40	20	55	21	20	*	0	10	48
Soybeans (bu)	30	32	33	43	34	55	*	50	21	47
Cotton, 120 Lbs. N Chemical Fertilizer[c]										
Seed Cotton (lbs)	1361	1522	1594	1735	2333	1445	2189	0	1258	1960

[a]Averaged over two plots.
[b]Averaged over three plots.
[c]One plot
*Plot mismanaged, no yield.

loss for this soil is three tons per acre per year (McNutt).

Estimated soil loss potential was highest where continuous cotton was produced with no nitrogen fertilizer or legumes (5.74 T./acre/yr.). The other systems have estimated erosion potentials of between 4.06 and 4.78 tons per acre per year. There is evidence that some erosion has occurred across the experimental area during the 92-year history of the test. However, this erosion has been relatively uniform across the cropping systems. In addition, the actual erosion was not considered large enough to be of impact on the cropping system and was therefore not considered to be significant for this study. Although not typically considered by farmers in the study region, risk-returns for permitted soil loss at three tons per acre per year were analyzed in the Target-MOTAD model at a $40,000 annual target income level.

ROTATION DATA

Objective function activities (equation 1) consisted of net returns above variable costs from rotations 1 (CtL), 3 (CtN), 5 (CtLCnN), and 6 (CtLCnS), as shown in Table 3. Rotations 2 (Ct) and 4 (CtLCn) resulted in average annual negative net returns above variable costs and were thus not included in the program objective function. Expected returns were defined as net returns above variable costs.

Technical resource constraints consisted of land, labor, and the deviations from target income (equations 2 and 3). One acre of land was required to produce one acre of crop activity up to a maximum of 570 acres of land. Labor requirements were restricted to a maximum of 300 hours per month. Deviation constraints related returns per period to

Table 2. Potential Annual Soil Losses From Sheet And Rill Erosion Due To Cropping Systems

Cropping System	C factor	Estimated Potential Soil Loss (T./Acre)
Continuous Cotton	.38	4.54
1. Winter Legume, No N	.48	5.74
2. No Legume, No N	.40	4.78
3. No Legume, With N		
Two-Year Cotton-Corn		
4. Legume, No N	.35	4.19
5. Legume, 120 Lbs. N	.35	4.19
Three-Year Cotton-Corn-Rye/Soybeans		
6. Winter Legumes, With N On Rye	.34	4.06

the target income level (equation 3). The last row (equation 4) summed negative deviations, under the assumption that deviations for each state of nature were equally likely (P_t). The summed deviations were used along with the parameterized value of G in generating the optimal risk-return frontier for a given value of T.

Rotations were constrained to a maximum of 340 acres of cotton in the optimal farm plan. Set-aside requirements were satisfied out of the optimal solution acreages. To satisfy rotation requirements, rotations CtLCn and CtLCnN consisted of 1/2 of the acreage in cotton and 1/2 in corn on an annual basis. Rotation CtLCnS allocated 1/3 of the land acres to cotton, 1/3 to corn, and 1/3 to rye/soybeans double-cropped in each year. It was further assumed that the farm manager participated in the farm program at the minimal set-aside required for 1988 (25 percent cotton and 10 percent corn) and that these acreages satisfied the respective program base requirements for participation in the program (Dicks *et al.).* Participation in the farm program was assumed because the calculation of net returns to the rotations indicated that, without the protection of the farm program, the only profitable rotation was the three-year rotation (CtLCnS).

Variable costs for associated machinery operations were incorporated in the net return estimates. For this analysis, custom rates were used for corn, rye, and soybean harvesting. It was assumed that sufficient planting, tillage, and cotton harvest machinery was owned for the alternative rotations.

Observations on the distribution of net returns over time (C_{tj}) were developed using yields from the historic data. Probabilities on these states of nature were assumed to be equally likely.

Table 3. Net Returns ($) Above Variable Costs Per Period (1978/79-1987/88) For Alternative Rotations

Period	Continuous Cotton With Legumes	Continuous Cotton Without Legumes		Two Years Cotton-Corn With Legumes	
	(0-80-60)[a]	(0-80-60)	(120-80-60)	(0-80-60) Cotton	(0-80-60) Corn
1	96.98	-188.18	-.98	23.17	-86.48
2	-11.49	-175.81	8.47	-59.15	-26.91
3	65.40	-124.03	85.22	53.18	-87.97
4	165.40	-114.77	95.37	143.48	-11.63
5	203.43	-107.16	152.51	176.79	59.67
6	6.68	-175.29	8.19	22.60	-43.46
7	230.87	-188.01	147.83	155.11	-77.76
8	-136.20	-202.48	-327.62	-70.23	-117.93
9	-89.21	-179.25	-30.49	-1.94	-15.08
10	18.83	-84.80	75.74	-25.30	-20.27
Mean	55.09	-153.98	21.42	41.77	-42.78
Std. Dev.	115.08	39.57	130.78	84.50	48.80
Skewness	.34	1.64	-.47	.67	-.47

Period	Two Years Cotton-Corn With Legumes		Three Years Cotton-Corn-Rye/Soybeans With Legumes		
	(120-80-60) Cotton	(120-0-0) Corn	(0-80-60) Cotton	(0-0-0) Corn	(60-0-0) Rye/Soy
1	52.67	-66.32	98.88	-28.27	177.78
2	-36.25	-51.98	89.05	-5.05	217.35
3	5.11	-85.64	279.11	-56.07	183.33
4	206.17	-32.18	284.77	-54.49	359.86
5	172.08	50.62	273.70	74.31	155.68
6	65.18	-74.90	178.49	-32.53	320.69
7	270.42	-110.58	256.24	-8.26	-90.93
8	-112.89	-123.58	-22.17	-118.84	211.99
9	97.17	-38.58	86.53	34.76	36.58
10	29.87	-18.58	50.41	-14.33	355.49
Mean	74.95	-55.17	157.50	-20.88	192.78
Std. Dev.	109.78	47.47	105.63	49.76	133.53
Skewness	.43	.25	.53	.03	-.11

[a] Values in parentheses are the annual rates of N-P_2O_5-K_2O applied per acre.

RESULTS

Results were analyzed for $60,000, $50,000, $40,000, $30,000, $20,000, and $10,000 target income levels for the four feasible rotations. The summary statistics shown in Table 3 indicate a moderate degree of skewness for the data. The mean net return over the entire data set was $35,910. The skewness for the entire data set was .39, indicating that the probabilities of target incomes of $40,000, $50,000, and $60,000 were somewhat greater than the probabilities of the lower target incomes.

Risk-returns for the alternative target income levels, where soil loss is not a binding constraint, are presented in Table 4. The results of the analysis, regardless of target income, showed that the three-year rotation of cotton, winter legumes-corn, and rye/soybeans double-cropped, gave the highest net return. The risk-return frontier of optimal results also showed that risk was reduced by substituting part of the three-year cotton, winter legume-corn, rye/soybean rotation with a continuous cotton-winter legume rotation. This substitution continued to take place up to the point where the negative deviations from target income became large enough to drive the system to infeasibility. The trade off of CtLCnS for CtL resulted in a lowering of net returns as risk was reduced.

Table 4. Risk-returns For Alternative Target Income Levels.

Target Income ($/Yr.)	Risk Level ($)	Expected Returns ($/Yr.)	Rotation (Acres) CtLCnS	CtL
10,000	6,290.91	62,586.00	570.00	.00
10,000	5,400.00	58,710.82	499.17	70.83
10,000	5,061.00	45,927.80	372.04	92.16
10,000	4,925.28	27,824.26	230.29	46.06
20,000	11,081.56	62,586.00	570.00	.00
20,000	10,500.00	60,788.72	537.15	32.85
20,000	10,000.00	58,189.89	489.65	80.35
20,000	9,850.57	55,649.71	460.60	92.13
30,000	16,761.69	62,586.00	570.00	.00
30,000	15,800.00	59,759.31	518.33	51.67
30,000	15,300.00	56,488.97	458.56	111.44
30,000	15,207.55	55,223.41	435.43	134.57
40,000	23,343.56	62,586.00	570.00	.00
40,000	22,355.00	58,820.20	501.17	68.83
40,000	21,704.00	54,646.15	424.87	145.13
40,000	21,635.08	52,851.57	392.07	177.93
50,000	31,000.78	62,586.00	570.00	.00
50,000	30,000.00	58,737.46	499.66	70.34
50,000	29,400.00	56,193.61	453.16	116.84
50,000	29,100.00	53,523.03	404.35	165.65
60,000	39,695.25	62,586.00	570.00	.00
60,000	38,218.00	58,685.27	498.70	71.30
60,000	38,000.00	57,381.95	474.88	95.12
60,000	37,406.34	51,987.50	376.39	193.72

At each target income level, the highest optimal return above variable costs resulted from using the three-year CtLCnS rotation. As target income was increased from $10,000 to $60,000, commensurately higher risk was incurred in achieving a given level of net return with a given combination of the rotations CtLCnS and CtL. For an expected return of $62,586 and a $10,000 target income level, a $6,290.91 risk must be incurred. A $39,695.25 risk was incurred for the same expected return at a $60,000 target income.

A production possibilities curve for the rotations and a $40,000 target income is shown in Figure 1. This curve shows that to achieve a $40,000 target income at a minimum feasible risk, a producer should plant approximately 392 acres (69 percent) in the three-year rotation CtLCnS and 178 acres (31 percent) in rotation CtL. A producer's preference for greater risk-taking will result in a higher proportion of CtLCnS being used in relation to the CtL rotation.

Table 5 shows the results of the analysis where soil loss was restricted to a total of 1,710 tons per year on the 570 acres. The optimal solutions at a $40,000 target income level indicated that a higher level of risk and a lower level of expected return must be incurred for the same level of target income where soil loss was a binding constraint. The highest expected return for the soil loss constrained solution was $46,245.81 on 421.18 acres of the three-year rotation CtLCnS, compared with $62,586 on 570 acres of the unconstrained soil loss three-year rotation. The respective levels of risk incurred were $25,430.38 for the soil loss constrained and $23,343.56 for the unconstrained rotation.

At the minimum feasible risk level, the results were fundamentally the same for the soil loss constrained and unconstrained rotations. The optimal

TABLE 5. RISK-RETURNS FOR ALTERNATIVE TARGET INCOME LEVELS, EROSION RESTRICTED TO THREE TONS PER ACRE PER YEAR.

Target Income ($/Yr.)	Risk Level ($)	Expected Returns ($/Yr.)	Rotation (Acres) CtLCnS	CtL
40,000	25,430.38	46,245.81	421.18	.00
40,000	25,000.00	44,576.67	393.61	24.66
40,000	24,650.00	42,144.73	353.43	60.59
40,000	24,341.50	37,799.36	281.65	124.78

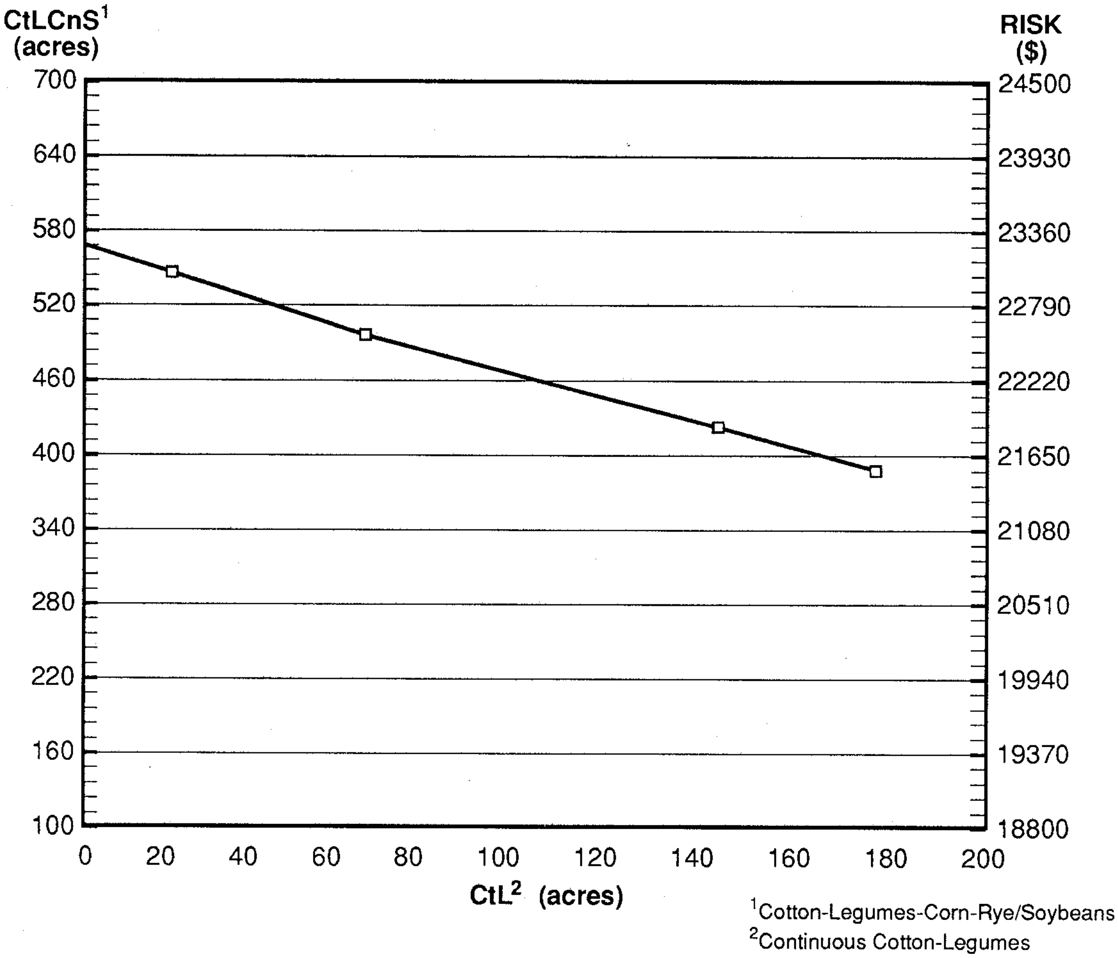

Figure 1. Optimal acreage versus risk, at a $40,000 target income, for alternative rotations of the 92-year "Old Rotation," *Auburn University, Alabama, 1978/79—1987/88.*

solution showed a substitution of approximately 31 percent of the CtL rotation for the CtLCnS rotation in both constrained and unconstrained cases. However, the risk was higher and net return lower for the constrained case.

SUMMARY AND CONCLUSIONS

This study compared the risk and returns from the past 10 years of Auburn University's 92-year "Old Rotation." Comparisons were made of sustainable, continuous cotton rotations to cotton and corn rotations, with and without nitrogen and winter legumes, and to a three-year rotation of cotton, legumes, corn, and rye/soybeans.

This Target-MOTAD model specified a set of optimal results for alternative target income and risk levels, subject to land and labor constraints. The method did not assume a level of risk or income preference. Rather, it calculated optimal results for alternative income and risk levels. The results are therefore presented as a range of feasible optimal rotation plans. The best plan for a producer will depend on attitudes toward risk in relation to the target income and expected returns.

Rotations including winter legumes outperformed rotations that included only petroleum-based N fertilizer by providing higher expected returns with less risk, for all levels of target income modeled. A combination of the CtLCnS and CtL rotations, rather than a single cotton rotation scheme, resulted in the least risk plan for all levels of target income. The inclusion of soil loss limits on the total farm acreage resulted in a reduced total acreage planted in the optimal farm plan but not in the rotations entering this plan.

The results showed that the optimal farm plan included the three-year CtLCnS rotation, regardless of soil loss constraint. Optimal farm plans in which the entire 570 acres was planted to the CtLCnS rotation showed a higher level of return and a higher risk level than those plans that incorporated the CtL rotation. As the level of risk was reduced, more of the continuous cotton with winter legume rotation entered the farm plan. The trade-off from reducing risk was a lowering of expected returns. The best strategy to minimize risk at each target income level included both the CtLCnS and CtL rotations in the farm plan. The risk minimizing proportion of CtL included in the farm plan ranged from 17 percent of the planted acres at a target income of $10,000 to 34 percent of the planted acres at a $60,000 target income (Table 4).

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