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STAFF PAPER

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A Yield Sensitivity Analysis of Conventional and Alternative Whole-Farm Budgets for a Typical Northeast Kansas Farm

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Abstract

This analysis compares net returns of conventional and alternative agricultural cropping systems in northeast Kansas, with and without government commodity programs. The highest net return is consistently from the alternative system, wheat/clover-sorghum-soybeans. Sensitivity analysis reveals that the economic performances of the alternative systems are sensitive to yield penalties.

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Introduction

Alternative agriculture can be defined as a system of food production that includes in its set of goals profitable production with concern for reduction in off-farm inputs; use of natural or biological processes; and improved management and conservation of soil, water, and other biological resources (National Research Council). Much research has been focused on the assessment of individual practices that can be used within an alternative agriculture system, such as tillage, crop selection, and reduced chemical and fertilizer levels. However, few experimental data exist documenting the effects of alternative whole-farm systems.

The National Research Council identified a paucity of research directed toward the many on-farm interactions among components of alternative agriculture, such as crop rotations, nutrient cycling, and tillage methods. This is largely due to inadequate funding, facilities, and incentives supporting farming systems research. Many states are overcoming these restrictions by establishing stronger relationships between laboratory research and progressive producers. Enhancing the relationship between controlled disciplinary research and its application on-farm may be the only way in which research institutes can afford to develop necessary long-term data on alternative agriculture practices.

The purpose of this study is to use available component information and additional systems information gathered from farmers to construct whole-farm budgets for a representative northeast Kansas farm. A unique feature of this study compares average historical yields and yields resulting from sensitivity analysis to those yields reported by producers currently using these systems.

Thus, an attempt is made to converge experimental and on-farm data. A yield sensitivity analysis is conducted to determine the stability of the budget results, if yield penalties should occur in crops under these systems.

Net returns and costs for a conventional farming system and four alternative farming systems for a typical northeast Kansas farm are developed and analyzed with and without the basic government commodity provisions. Costs for the field operations in the alternative farm systems are based on actual farm operations that are currently in use in northeast Kansas. The conventional farming system (Conventional) has five individual crop rotations. However, the four alternative farming systems examined are whole-farm rotations.

Conventional:	corn-soybean, sorghum-soybean, wheat-sorghum, wheat-soybean, and continuous corn
Alternative 1:	wheat/clover-sorghum-soybean
Alternative 2:	sorghum-wheat/vetch
Alternative 3:	alfalfa/oats-alfalfa-alfalfa-wheat-soybeans
Alternative 4:	corn-soybeans-corn-soybeans-alfalfa/oats-alfalfa-alfalfa

The Representative Farm

Kansas Farm Management Association data for 14 northeast Kansas counties for the period 1986-1990 are used in determining farm size, tenure arrangements, and crop acreages for the representative farm. A weighted average of 332 total farms are used in this study. The average dryland cropland for these farms is approximately 640 acres, with 37 percent owned and 63 percent rented.

Cropping Systems

Conventional System

Crop rotations common in northeast Kansas are identified and included in the Conventional system and allocated based on the total crop acreages. The 640 acres of the representative farm are distributed among four major crops in the Conventional system: wheat (110 acres), grain sorghum (125 acres), soybeans (250 acres), and corn (155 acres). Because these crops are typically grown in rotations, the numbers are rounded slightly to reflect this. Figure 1a provides a schematic of the crop acreage and rotation layout for the Conventional system. Corn is grown on 125 acres in rotation with soybeans. An additional 30 acres of corn is cropped in a continuous sequence. Soybeans are grown in rotation with corn on 125 acres, 70 acres are rotated with sorghum, and 55 acres are rotated with wheat. Sorghum is produced on 70 acres in rotation with soybeans and 55 acres in rotation with wheat. Wheat is grown on 55 acres in rotation with soybeans and on an additional 55 acres in rotation with sorghum.

Alternative Systems

On-farm personal interviews with 15 northeast Kansas farmers currently using alternative cropping practices are used to identify alternative cropping systems. Crop rotations, operation schedules, yields, and equipment descriptions were collected from each participant. Four alternative systems that are used by several producers are selected for analysis; their crop acreages and rotations are illustrated in Figure 1b-e.

Alternative 1 has 213.3 acres allocated to wheat interplanted with clover. The clover serves as a nurse crop for wheat, as well as a nitrogen source and is harvested after wheat for hay. An additional 213.3 acres are planted to sorghum, and the remaining 213.3 acres are used for soybeans.

In Alternative 2, the total acreage is divided equally with 320 acres planted to sorghum annually and 320 acres utilized for wheat and vetch. Vetch, a legume, is used as a nitrogen source, similar to clover in the previous system; however, it is not harvested. Vetch is seeded after fall harvest of wheat, killed, and disked in the spring before sorghum is planted.

Alternative 3 is a whole-farm rotation where alfalfa accounts for a total of 384 acres. Each year, 128 acres of new alfalfa interseeded with oats is planted on land on which soybeans were harvested in the previous year. Alfalfa is harvested once in year 1, three times in year 2, and once in year 3. Oats are harvested and the straw is baled 1 month before the single harvest of alfalfa in the first year. After alfalfa is harvested in year 3, it is incorporated into the soil as a green manure for the subsequent year's wheat crop. The land that produces alfalfa for the third year in a row is planted to wheat in the following fall and to soybeans in the spring after wheat harvest.

Alternative 4 has 183 acres planted to corn and rotated with soybeans. The following spring, one-half of the soybean acreage (91 acres) is planted to alfalfa interseeded with oats. The remaining soybean acreage returns to corn. There is a total of 273 acres of alfalfa each year: 91 acres of newly planted alfalfa, 91 acres of second-year alfalfa, and 91 acres of third-year alfalfa. Harvesting of alfalfa does not occur in year 1, but alfalfa harvesting occurs three times in years 2 and 3. Oats are harvested and the straw is baled in late-summer on the land with first-year alfalfa. The final year of alfalfa is incorporated to provide nitrogen from fixation for the following corn crop.

Budgeting Procedures

Crop enterprise and whole-farm budgets are used to estimate the annual operating expenses and machinery costs of each rotation and system and to provide a projection of expected revenue. Costs and returns are estimated for the conventional system and the four alternative systems. Several of the key elements of the budgets are described here. For more detail refer to Diebel, Llewelyn, and Williams.

Machinery

Machinery requirements and costs are determined based on field operations required of each system, farm size, field operation timing, available field workdays, and field workday length. A machinery complement suitable to perform the specific field operations of each system is determined. A different machinery complement exists for the conventional system and each of the four alternative systems.

Prices

Crop prices are the annual season average prices from the northeast district of the Kansas Crop and Livestock Reporting Service (Kansas Agricultural Statistics) for the period 1986-1990. Because a separate northeast district price is unavailable for alfalfa, the average price for all hay is used (Kansas Agricultural Statistics). Prices in this analysis are: wheat, \$3.04 per bushel; corn, \$2.07 per bushel; sorghum, \$1.87 per bushel; soybeans, \$5.72; and alfalfa, \$57.45 per ton.

Yields

Yield data for wheat, corn, grain sorghum, soybeans, and alfalfa are from Kansas Farm Management Association data for northeast Kansas and represent the weighted average of the total farms in the 14 counties for the period 1986-1990. These yields are used for all of the systems despite the fact that yield variations may exist between different systems. Experimental field data for these systems are not available. Yields are: wheat, 34.3 bu. per acre; corn, 86.1 bu. per acre; sorghum, 74.5 bu. per acre; soybeans, 31.1 bu. per acre; and alfalfa, 2.8 tons per acre. These yields are within the range of average yields reported by the farmers surveyed, see Table 3, footnote e (Diebel, Williams, and Llewelyn).

Input Costs

In formulating the enterprise budgets, the variable costs of labor, fuel, oil, and machinery repairs are calculated for each field operation. Costs for seed, fertilizer, and pesticides are calculated based on application rates. Fixed costs of insurance, interest, and depreciation are determined for each implement, and land costs are calculated for owned and rented land. All costs are calculated on a per acre basis for the whole-farm analysis.

Government Commodity Program

The 1992 program provisions under the 1990 FACTA are used to estimate net returns. Base acreage is assumed to be the same as planted acreage in the Conventional system. When commodity program crops are planted, 5 percent of base is allocated to set-aside, and 15 percent to flex acres. Flex acres are planted to the respective program crop and receive no deficiency payments.

Target prices are from the 1992 program provisions, and program yields are the weighted average yields of 1980-1984 area yields (Kansas Farm Management Association).

Comparison of Budget Results

The net returns to management, gross returns, and variable costs per acre are presented in Table 1. Among the conventional and four alternative production systems, Alternative 1 has the highest returns, \$29.09 and \$46.05 per acre with and without government subsidies, respectively. Alternative 2 consistently has the lowest net returns, \$-36.08 and \$-8.01 per acre, respectively. This system has negative returns despite receiving the highest deficiency payments, because no returns are received from the vetch crop in this rotation.

Significant variation occurs in the variable costs of each system. Some selected variable costs are shown in Table 2. The low total variable costs of Alternative 4 are partly due to low or zero pesticide and fertilizer expenditures. However, labor for this system is nearly twice that of Alternative 1 because of labor-intensive nonchemical weed control methods. Alternative 2, the poorest performer, requires the largest amount of fertilizer despite the use of a legume crop. Fertilization levels are based on current practices, not on a nitrogen-balanced strategy. The low maintenance and the single planting of alfalfa for a 3-year production period keeps variable costs low for Alternatives 3 and 4.

Changes in ranking of net returns with program participation are linked to the relative value of market returns (gross return) and deficiency payments per acre. Those systems that move up in rank under government programs do so because the reduction in gross returns (due to set-aside and Flex requirements) is considerably less than the gain from deficiency payments. For example, participation in the government commodity program results in a \$4.41 per acre reduction in gross returns of the Conventional system but a \$20.19 deficiency payment per base acre. Net gain from program participation for the Conventional system is \$15.78 per acre (Table 1). Alternative 3 ranks behind the Conventional system with government subsidies because its net gain is only \$4.42 per acre.

The Conventional system has relatively high variable costs (fourth highest) partly due to pesticide costs. Only Alternative 2 has substantially higher costs. Gross returns of the Conventional system are not as high as those of Alternatives 1 and 4 with government program participation. This results in the Conventional system being economically outperformed by several alternative systems even with deficiency payments.

The variable costs in the alternative systems using legumes may in reality be lower than estimated here because of potential nitrogen credit from the legumes, which is not accounted for in this study. Fertilizer levels are based on the survey information collected from area farmers. The accuracy of the estimated available nitrogen from organic and commercial sources and actual plant needs is unknown. A detailed nitrogen balance analysis would consider plant needs and the nitrogen available from legumes and soil and suggest addition of commercial fertilizer to make up the difference. However, this difference may be less than actually applied.

Yield Sensitivity Analysis

Few field data are available to account for the variation of crop yields under various cropping systems. Research of this type requires extensive funding, land, and time to produce accurate results. In order to address this problem, a sensitivity analysis is conducted and compared to the average yield reported by interviewed producers (Table 3).

Alternatives 1, 3, and 4 had net returns superior to the Conventional system, without government program participation, and are subject to sensitivity analysis. The crops common to the Conventional system (corn, wheat, soybeans, and sorghum) are reduced individually and then simultaneously by the same proportion until their net returns are equal to that of the Conventional system. Alternative 1 is the most profitable system and, therefore, requires the largest reductions.

Under government program subsidies, only Alternative 1 and 4 are subjected to sensitivity analysis. Again, Alternative 1 requires the largest reductions to equate net returns. The penalties with government program participation are expected to be larger, because actual yield changes do not affect program yields. This is true for Alternative 1. However, Alternative 4 requires smaller penalties because of the difference in deficiency payments being made to it and the Conventional system. The Conventional system receives deficiency payments of $20.19 per acre, whereas Alternative 4 receives a much smaller payment of $9.96 per acre. The relative difference in these payments puts Alternative 4 at a disadvantage, making it more sensitive to yield variation.

Many yields remain within reported average yield ranges after penalties are imposed. However, wheat yield penalties in Alternative 1 force production below the reported range, whether reduced alone or with other crops. Sorghum yields in Alternative 1 fall below the reported yields when penalized individually. Soybeans and corn consistently remain within the possible yield range despite penalties. Therefore, Alternative 1 appears to be a feasible alternative system, requiring large yield penalties before its net returns are surpassed by those of the Conventional System. Alternatives 3 and 4 may not be as economically feasible, if yields are lower than average yields.

Summary and Conclusions

Alternative cropping systems, which are constructed from information gathered from northeast Kansas farmers, expert opinion, and other available data in Kansas, have the potential to produce higher net returns to the producer. Without government program participation, three of the alternative systems rank higher than the Conventional system. Alternatives 1 (W/Cv-Sg-Sb), 3 (A1/O-A2-A3-W-Sb), and 4 (C-Sb-C-A1/O-A2-A3) have very attractive net returns compared to the Conventional system. With government participation, Alternatives 1 and 4 again have higher net returns than the Conventional system.

When crop yields are reduced individually, fairly severe yield penalties for wheat and sorghum are necessary to reduce net returns to the same level as those of the Conventional system. Otherwise, the penalized yields are within the range of yields reported by producers using these systems. This analysis indicates the net returns of some alternative systems are greater than those of the conventional system, although sensitive to yield variation and deficiency payments.

Recommendations for Further Research

Further analysis will consider alternative provisions of the 1990 FACTA, such as the Integrated Farm Management Program. The nitrogen contributions from legumes will be estimated and credited in future analysis, as well. Another step of analysis will include the assessment of potential environmental benefits and costs from these systems, such as water quality and soil erosion impacts.

References

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Table 1. Whole Farm Gross and Net Returns per Acre With and Without Government Commodity Programs and Deficiency Payments

Cropping System[a]	Total Variable Cost per Acre (Rank)[b]	Without Government Program: Gross Returns per Acre (Rank)[c]	Without Government Program: Net Return per Acre (Rank)[c]	With Government Program: Gross Return per Base Acre (Rank)[c]	With Government Program: Net Return per Base Acre (Rank)[c]	With Government Program: Deficiency Payments per Base Acre (Rank)[c]
Conventional	$58.16 (4)	$157.78 (2)	$10.64 (4)	$153.37 (3)	$27.72 (3)	$20.19 (3)
Alternative 1	$56.26 (3)	167.46 (1)	29.09 (1)	162.06 (1)	46.05 (1)	21.07 (2)
Alternative 2	$70.94 (5)	121.79 (5)	-36.08 (5)	115.70 (5)	-8.01 (5)	31.61 (1)
Alternative 3	$33.61 (1)	129.31 (4)	12.77 (3)	128.26 (4)	17.40 (4)	5.47 (5)
Alternative 4	$39.07 (2)	157.58 (3)	26.99 (2)	155.05 (2)	34.75 (2)	9.96 (4)

[a]Conventional - C-Sb,Sg-Sb,W-Sb,W-Sg,C-C; Alternative 1 - W/Cv-Sg-Sb; Alternative 2 - Sg-W/V; Alternative 3 - A1/O-A2-A3-W-Sb; Alternative 4 - C-Sb-C-Sb-A1/O-A2-A3.

[b]The rank of 1 is the lowest value.

[c]The rank of 1 is highest value.

Table 2. Selected per Acre Costs of Whole-Farm Cropping Systems

Cropping System	Labor	Custom Hire	Fuel and Oil	Pesticides	Fertilizer	Interest on Variable Costs	Total Variable Cost per Acre (Rank)[b]
Conventional	$6.59	$3.02	$3.45	$14.32	$5.36	$3.29	$58.16 (6)
Alternative 1	5.57	0.00	3.02	9.02	5.47	3.18	56.26 (4)
Alternative 2	6.89	5.97	3.63	11.82	13.70	4.02	70.94 (9)
Alternative 3	7.51	0.00	3.08	0.00	.48	1.90	33.61 (1)
Alternative 4	10.28	0.00	3.44	0.00	0.00	2.21	39.07 (2)

[a]Conventional - C-Sb,Sg-Sb,W-Sb,W-Sg,C-C; Alternative 1 - W/Cv-Sg-Sb; Alternative 2 - Sg-W/V; Alternative 3 - A1/O-A2-A3-W-Sb; Alternative 4 - C-Sb-C-Sb-A1/O-A2-A3.

[b]The rank of 1 is the lowest value.

Table 3. Yield Reductions in Alternative Systems that Equate Their Net Returns to the Conventional System Net Return

Cropping System[a]	Individual Yield Reductions of Similar Crops[b]				Simultaneous Yield Reductions of Similar Crops[c]			
	Corn[d]	Wheat[d]	Soybean[d]	Sorghum[d]	Corn	Wheat	Soybean	Sorghum
<u>Without Government Program</u>								
Alternative 1		-63.0% (12.7 bu/A)[e]	-37.0% (19.6 bu/A)	−47.1% (39.4 bu/A)[e]		-15.6% (28.9 bu/A)[e]	-15.6% (26.2 bu/A)	-15.6% (62.9 bu/A)
Alternative 3		-12.2 (30.1)	-7.1 (28.9)			-4.5 (30.4)	-4.5 (27.5)	
Alternative 4	-38.3 (53.1)[e]		-38.4 (19.2)		-19.2 (69.6)		-19.2 (25.1)	
<u>With Government Program</u>								
Alternative 1		-66.5% (11.5 bu/a)[e]	-36.7% (19.7 bu/a)	-50.2% (37.4 bu/A)[e]		-16.1% (28.8 bu/A)[e]	-16.1% (26.1 bu/A)	-16.1% (62.5 bu/A)
Alternative 4	-17.5 (71.0)		-16.6 (25.9)		-8.4 (78.9)		-8.4 (28.5)	

[a]Alternative 1 = W/Cv-Sg-Sb; Alternative 2 = Sg-W/V; Alternative 3 = A1/O-A2-A3-W-Sb; Alternative 4 = C-Sb-C-Sb-A1/O-A2-A3.

[b]Yields of each of the major crops (corn, wheat, soybeans, and sorghum) are reduced individually, until the net return is equivalent to the net return of the Conventional system.

[c]Yields of all of the major crops (corn, wheat, soybeans, and sorghum) are reduced simultaneously by the same percentage until the net return is equivalent to the net return of the Conventional system.

[d]The base yields for these crops are: corn, 86.1 bu/A; wheat, 34.3 bu/A; soybeans, 31.1 bu/A; and sorghum, 74.5 bu/A.

[e]The yield is less than the lowest average yield reported in surveys of northeast Kansas farm managers. The reported range of average yields are: wheat 30-50 bu. per acre; corn, 60-110 bu. per acre; soybeans, 15-48 bu. per acre, and sorghum, 40-125 bu. per acre.

a. Conventional: corn-soybean (C-Sb), sorghum-soybean (Sg-Sb), wheat-sorghum (W-Sg), wheat-soybean(W-Sb), and continuous corn (C-C).

Corn (in C-Sb rotation) 125 acres	Sorghum (in Sg-Sb rotation) 70 acres	Sorghum (in W-Sg rotation) 55 acres	Wheat (in W-Sg rotation) 55 acres	Corn (in C-C rot.) 30 acres
Soybeans (in C-Sb rotation) 125 acres	Soybeans (in Sg-Sb rotation) 70 acres	Soybeans (in W-Sb rotation) 55 acres	Wheat (in W-Sb rotation) 55 acres	

Corn: 155 acres
Soybeans: 250 acres
Sorghum: 125 acres
Wheat: 110 acres

b: Alternative 1: Wheat/Clover-Sorghum-Soybeans (W/Cv-Sg-Sb)

Wheat/Clover 213.3 acres	Sorghum 213.3 acres	Soybeans 213.3 acres

Wheat: 213.3 acres
Clover: 213.3 acres
Sorghum: 213.3 acres
Soybeans: 213.3 acres

c: Alternative 2: Sorghum-Wheat/Vetch (Sg-W/V)

Wheat/Vetch 320 acres	Sorghum 320 acres

Wheat: 320 acres
Vetch: 320 acres
Sorghum: 320 acres

d: Alternative 3: Alfalfa 3 years-Wheat-Soybeans (A1/O-A2-A3-W-Sb)

Wheat 128 acres	Soybeans 128 acres	Alfalfa/Oats (1st year) 128 acres	Alfalfa (2nd year) 128 acres	Alfalfa (3rd year) 128 acres

Wheat: 128 acres
Soybeans: 128 acres
Alfalfa: 384 acres
Oats: 128 acres

e: Alternative 4: Corn-Soybeans-Corn-Soybeans-Alfalfa 3 years (C-Sb-C-Sb-A1/O-A2-A3)

Corn 183 acres	Alfalfa/ Oats (1st year) 91 acres	Alfalfa (2nd year) 91 acres	Alfalfa (3rd year) 91 acres
Soybeans 183 acres			

Corn: 183 acres
Alfalfa: 273 acres
Oats: 91 acres
Soybeans: 183 acres

Figure 1. Conventional and alternative cropping systems for a northeast Kansas representative farm.