STAFF PAPER

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A Risk Analysis of Crop
Rotations in Southeast Kansas Including
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ABSTRACT

Six rotations, four of which include a sequence of wheat followed immediately after harvest by double-cropped soybeans, are evaluated with the option of participating in the government commodity program. Stochastic dominance analysis is used to evaluate these rotations for net return risk. Analysis indicates that risk-averse managers out of the government commodity program prefer an annual crop rotation of wheat and double-cropped soybeans. Risk-averse managers who feel participation in the government commodity program is an essential risk management tool prefer a three-year rotation of grain sorghum, full-season soybeans, and wheat with double-cropped soybeans.

A Risk Analysis of Crop Rotations in Southeast Kansas Including Double-Crop Alternatives

Cropping sequence alternatives have recently received more attention at both the experimental and actual field level as possible income-enhancing and stabilizing strategies. Participation in the government commodity program reduces risk, but also reduces the flexibility of the farm to change rotations. The government program also does little to reduce income risk from to yield variability, which can be considerable in crop rotations that include double-cropping (the practice of planting a second crop immediately after harvesting the first). The relatively demanding growing conditions, increased management requirements, and the potential for lower and more variable yields from double-cropping may increase the farm's exposure to risk.

This study focuses on double-crop soybeans and wheat. The success of double-crop soybeans following wheat depends on 1) adequate soil moisture at planting to ensure germination, 2) sufficient rainfall during the extended growing period, and 3) enough time for the second crop to mature before frost (Lamond et al.; Parsch et al.; and Woodruff et al.). Although additional risks and expenses are involved in double-cropping, price and production uncertainties are spread over both crops, which may stabilize income and boost farmers' credit worthiness (Hexem and Boxley).

In a double-crop system, wheat and soybeans do not compete for the capital and labor needed for planting most other crops (Marra and Carlson). Possible reasons for this are the time- and cost-efficient operations involved in the double-cropped system. Spreading fixed costs of production (such as managerial time, labor, and machinery) over both crops reduces per unit production costs. In addition, residual plant nutrients can be used for wheat following soybeans[1]. Though the yield of individual crops in a double-crop rotation may be lower than that for a single-crop rotation, net returns may be comparable or higher because of reduced per unit production costs. The possibility of returns below those of single-cropping remains, however, because not much is known about the profitability of double-cropping in combination with other crop enterprises (Hexem and Boxley). The net returns and risk of double-crop sequences in combination with other cropping alternatives are considered in this paper.

This study presents an analysis of expected returns from six crop rotations applicable to actual farming units in southeast Kansas. Expected net returns over variable costs are calculated and the variability of these net returns are examined using stochastic dominance with respect to a function (SDRF). The impact of the commodity provisions of the 1985 Food Security Act on crop rotations is examined as well.

CROPPING PRACTICES

The six crop rotations studied are as follows:

1) R1: WDCSB - a one-year rotation of wheat and double-cropped soybeans.

2) R2: WDCSB-FSSB - a two-year sequence of 1) wheat and double-cropped soybeans and 2) full-season soybeans.

3) R3: W-W-FSSB - a three-year sequence of 1) wheat, 2) wheat, and 3) full-season soybeans (no double-cropping).

4) R4: W-WDCSB-FSSB - a three-year sequence of 1) wheat, 2) wheat and double-cropped soybeans, and 3) full-season soybeans.

5) R5: SOR-FSSB-WDCSB - a three-year sequence of 1) sorghum, 2) full-season soybeans, and 3) wheat and double-cropped soybeans.

6) R6: SOR-FSSB-W - a three-year sequence of 1) sorghum, 2) full-season soybeans, and 3) wheat (no double-cropping).

Rotations 1, 2, and 3 are cropping sequences that are being studied at the Southeast Kansas Branch Experiment Station in Columbus. Annual yield data are available for each crop in each rotation. Rotations 4, 5, and 6 are typical crop rotations currently used in southeast Kansas.

PROCEDURES

Variable input requirements are determined for each crop rotation, based on machinery operations for a typical farm and recommended agricultural experiment station cropping practices. Specific costs by individual field operation are calculated and organized into a whole-farm budget for each cropping sequence. It is assumed that the machinery complement typical to southeast Kansas farms can handle each of the alternative crop rotations.

A distribution of net returns over variable costs for each system is calculated using yield and price data from 1982 to 1986 and 1986 costs. Thus, this study focuses on yield and output price variability. Potential annual net returns are then calculated based on the loan rates, target prices, and set-aside and diversion levels specified by the Food Security Act of 1985 for the 1987 crop year. Stochastic dominance analysis is then used to select efficient cropping strategies by comparing the cumulative probability distribution of possible returns from each strategy.

This study utilizes first degree stochastic dominance (FSD), second degree stochastic dominance (SSD), and stochastic dominance with respect to a function (SDRF). The latter is a generalized version of FSD and SSD and is more flexible and discriminating, though it does require more specific information about the decision maker's preferences (King and Robison, 1984). A summary of stochastic dominance efficiency criteria can be found in Cochran, Robison, and Lodwick.

Stochastic dominance uses risk preference intervals determined with the Pratt absolute risk aversion function, R(x). This function, defined by Pratt as $R(x) = -U''(x)/U'(x)$, represents the ratio of derivatives from the decision maker's utility function, U(x). First degree stochastic dominance rules identify strategies preferred by the individual whose utility is a positive function of income. The criteria are consistent for individuals who prefer more income to less. Second-degree stochastic dominance criteria identify strategies preferred by individuals receiving greater satisfaction from increases in low levels of income than increases at high levels of income.

For SDRF, risk preference intervals bounded by lower and upper risk aversion coefficients, $R_1(x)$ and $R_2(x)$, are established by the researcher. King and Robison (1981) have suggested that most intervals should be established between the range of -0.0001 and 0.001. For example, suppose that R(x) is 0.001/$. This indicates that the manager's added utility or satisfaction for an additional dollar is decreasing at a rate of .01% per dollar increase in net return. Likewise, the value R(x) = 0.00001/$ indicates that it is falling at a rate of .001% per dollar of additional return. In the case of R(x) = 0.0001, the manager receives less satisfaction from an increase in income than if R(x) = 0.00001. Therefore, an interval can be defined near 0.0001 that is said to be more risk-averse than an interval near 0.00001, because less satisfaction from an additional dollar of income is derived in the former case than in the latter.

Seven risk preference intervals are used for the SDRF analysis. These intervals are assigned within the range suggested by King and Robison (1981). Risk-neutral behavior is generally assumed to be exhibited within the range of -0.00001 to 0.00001. Decision makers with R(x) values above this range exhibit more risk-averse behavior (the interval, 0.00005 to 0.0001, would be characterized as strongly risk-averse), whereas values below this range would be characterized by less risk-averse behavior. For FSD, the interval is $R_1(x) = -\infty$ and $R_2(x) = +\infty$, and the interval for SSD is $R_1(x) = 0$ and $R_2(x) = +\infty$. Stochastic dominance analysis was conducted using an optimal control algorithm developed by Raskin, Goh, and Cochran.

DATA

Yields

Yield data for wheat, full-season soybeans, and double-cropped soybeans were collected from a Southeast Kansas Branch Experiment Station study concerning the yield effects of alternative cropping sequences. In 1986, the wheat crop was destroyed by severe weather in January, so spring oats were planted in the experimental plots in late February. For farmers out of the government program, the distributions of net returns that include wheat are based on the probability that the wheat crop will fail once every five years and oats will be planted and harvested. When producing under the government commodity program, the yield and costs for the oat crop are not included in constructing the net return distributions. The yield data for sorghum are based on the average results of performance tests conducted by the experiment station from the period 1982 through 1986.

Prices and Costs

Wheat, soybean, and sorghum prices are the annual average prices received by farmers in the southeast district of the Kansas Crop and Livestock Reporting Service. Variable costs are based on price quotes from Kansas Farm Management Handbook for 1986 and actual per acre amounts of seed, fertilizer, chemicals, and other inputs used in the experiment station studies. Fuel, lubrication, and machinery repair costs are based on typical field operation requirements. Total variable costs are calculated for 600 acres of cropland when the farm does not participate in the government commodity programs. For one-year crop sequences, all 600 acres are in the indicated crops. For two- and three-year rotations, 300 and 200 acres are planted to each of the crops in the rotations. The effect of government program acreage restrictions are described later in this report.

The amount of cropland (600 acres) is based on data from farms in the Southeast Kansas Farm Management Association (Langemeier and Parker). The field time requirements for the crop enterprises are determined by specifying a machinery complement and the time requirements for each field crop operation with this complement. The number of machinery hours per acre (field time required) and machinery operating costs (fuel, lubrication, and repairs) are based on the 1986 Doane's Agricultural Report[2]. Machinery operations for each crop rotation are based on typical practices. One 140 hp tractor and one 70 hp tractor are assumed to be available on the farm. Labor requirements (hours) are estimated by multiplying the field time hours by a factor of 1.3 (Langemeier et al.).

ANALYSIS AND RESULTS

Net returns (returns to land, capital, and management) are calculated for each crop rotation for each year using annual yield and price data. Fixed costs are not specifically considered, since no change in land and equipment requirements are considered to be required for one crop rotation versus another.

Non-Participation in the Government Commodity Program

The distribution of net returns for each crop rotation without government program participation is displayed in Table 1. Rotation 1 (R1), a one-year double-cropping sequence of wheat followed by soybeans, has a substantially higher average net return than any other rotation. It also has the most risk as measured by the standard deviation. Its relative variability as measured by the coefficient of variation, however, is less than rotations R3 and R4. The rotations that contain sorghum have substantially lower variability, measured by the standard deviation, and relative variability, measured by the coefficient of variation. Although sorghum is the highest yielding crop, the standard deviation is smaller than that for wheat in any rotation.

Government Commodity Program Impact

Three general objectives of the Food Security Act of 1985 are to stabilize commodity prices, reduce crop surpluses, and increase farm income. Agricultural commodity program payments can affect the variability and level of farm income and influence the selection of cropping sequences. However, program restrictions also can reduce the opportunity for changing cropping systems. Loan rates, target prices, acreage reduction requirements, and optional paid land diversion for the 1987 crop year (Table 2) are used to generate cumulative probability distributions for evaluation.

Under the conditions of the government commodity program, it is assumed that full-season soybeans are planted on any idle land that is not included in set-aside acres. For rotations that do not include full-season soybeans, the soybean yields are the average of yields from the other rotations reduced by 10%[3]. In addition, costs and returns of spring oats production are not included for 1986, since a farmer could not plant oats after a wheat failure and still remain eligible for government commodity payments. Net returns are negative for wheat in 1986, when wheat was destroyed by severe weather.

The distributions of net returns under the government commodity program conditions are listed in Table 3. The three-year rotation of sorghum, full-season soybeans, and wheat double-cropped with soybeans under the government commodity program (R5-G) and the government commodity program with optional paid sorghum diversion (R5-D) have the highest average net returns. The three-year rotations of sorghum, full-season soybeans, and wheat under the government commodity program (R6-G) and with the optional paid sorghum diversion (R6-D) have the lowest variability as measured by the standard deviation and relative variability as measured by coefficient of variation.

The government commodity program reduces net return variability faced by the farmer when compared to non-participation. However, the average net return also declines when the rotations are in the government commodity program. The smallest decline is for rotation R6. In addition, the average net returns for the rotations including wheat decline because net returns for oats planted when wheat fails are not included. The addition of the optional paid land diversion for grain sorghum in rotations R5 and R6 has little effect on risk and actually increases the standard deviation and coefficient of variation by a small amount. The addition of optional paid sorghum diversion causes a decline in the average net return of the systems containing sorghum (R5 and R6). In four of the five years considered, the annual net returns are higher when the optional sorghum diversion is included (Table 3). For the year in which they are not, however, grain sorghum yield is considerably higher than the government program yield, so there is a substantial cost associated with removing the additional land from production.

Stochastic Dominance

Stochastic dominance analysis is conducted for four scenarios in which the farmer may choose between participating or not participating in the government program (Table 4). The rotations without government program participation are evaluated along with the rotations including government program participation, both with and without the use of the optional paid land diversion for grain sorghum. Stochastic dominance analysis indicated that the one-year double-crop rotation of wheat followed by soybeans was preferred in all risk aversion intervals (Table 4). This rotation had the largest minimum and maximum returns of any of the rotations in any year (Table 1). The fact that essentially 1200 acres of crops are produced (two crops of 600 acres each) is particularly important in generating the high average returns.

Some farmers may view current participation in government programs essential to qualify for future government payments and other farm programs, given the current political and agricultural policy environment. Thus, a farm plan that does not include commodity program participation for wheat and grain sorghum would not be acceptable to such farm managers. Therefore, a separate analysis of only the rotations including government program payments is conducted using stochastic dominance. With the basic government program, the three-year rotation of sorghum, full-season soybeans, and wheat with double-cropped soybeans (R5-G) is preferred by risk-averse individuals. A similar result is obtained when the optional paid land diversion for sorghum is included (Table 4).

When all combinations of participation and non-participation are considered, one system is dominant. The one-year rotation of wheat double-cropped soybeans without government program participation (R1) is the preferred system with and without government program participation in all risk aversion intervals (Table 4). Even though this system has the highest standard deviation and relative variability compared to other systems, the minimum net return of $37,784 is greater than that of any other system, including those with government payments. The large number of crop acres harvested (two crops for each acre which is substantially reduced by participating in the government program) in this rotation is a substantial factor in its selection as the preferred system.

Sensitivity Analysis

Because the yield data are obtained from experimental plot rotations and extrapolated to a larger acreage (commercial fields) for this analysis, they must be viewed with caution. Double-cropping requires a high degree of management expertise and favorable weather and soil conditions to be successful. It requires harvesting the first crop and planting the second crop within a short time period, which may not be difficult to complete on small experimental plots. However, a farm manager would have a more difficult time completing all field operations for the entire acreage every year. Custom combining is not normally available in southeast Kansas. An operator would need an adequate amount of qualified labor and would probably need two combines to double-crop 600 acres each year. On many farms, labor and field time constraints would limit the number of double-crop soybean acres.

Sensitivity analysis is conducted to determine how a reduced number of acres planted to soybeans after wheat harvest affects the dominant strategy (R1) without participation in the government commodity program. Using second degree stochastic dominance criteria, the analysis showed that if less than 214 acres of soybeans were double-cropped in the year 1984, 524 acres in 1985, or 506 acres in 1986, rotation R5, which contains only 200 acres of wheat and double-cropped soybeans, would be preferred equally to R1. If only one occurrence of these acreages could have been planted in those years, the minimum net return for rotation R1 would be less than that for R5. Further reductions in double-cropped soybean acreage would be required before any rotation having no double-cropped soybeans would be preferred equally to R1.

An analysis involving the magnitude of a parallel shift of the dominant distribution (R1) that is necessary to eliminate its dominance and produce an efficient set containing both the previously dominant distribution and the specified alternatives is also completed (Table 5). Using the risk-averse interval, .00005 to .00001, showed that if the wheat and double-cropped soybean distribution (R1) is lowered by a parallel shift of $11,825, the rotation of sorghum, full-season soybeans, and wheat (R6) enters the efficient set. This is equivalent to either lowering the double-crop soybean yield by 3.4 bu./acre or planting only 412 acres of double-crop soybeans per year. If the manager could only plant 416 or 518 acres of double-cropped soybeans in rotation R1, then rotations R2 and R5 would enter the efficient set. Rotation R5 contains only 200 acres of double-cropped soybeans, and R2 contains 300 acres of double-cropped soybeans.

Sensitivity analysis is also conducted to determine how sensitive the results are for rotations that are in the government commodity program. If the R5-G distribution is lowered by a parallel shift of $3,295 or $3,557 in the risk-averse interval, .00005 to .00001, the three-year rotation of sorghum, full-season soybeans, and wheat (R6-G and R6-D) enters the efficient set (Table 5). This is equivalent to a 4 bu./acre or 4.4 bu./acre decline in yield or planting only 84 or 79 acres of double-cropped soybeans instead of

140 acres in rotation R5-G.

Sensitivity analysis using second degree stochastic dominance is conducted to determine how a reduced number of acres planted to soybeans after wheat harvest in rotation R1 would affect the results when the rotations under the government commodity program are included with those rotations not in the government program. If less than 486 acres of soybeans were double-cropped in 1985 or 467 acres in 1986, rotation R6-G would be preferred equally to rotation R1. Slightly larger acreage reductions would be required to make R5-D and R5-G equally preferred. Sensitivity analysis using a parallel shift of the dominant distribution (R1) is also conducted using the risk-averse interval, .00005 to .00001. If the wheat and double-cropped soybean distribution (R1) is lowered by parallel shifts of $5,190, $6,030, and $6,181, the three-year rotations of sorghum, full-season soybeans, and wheat with double-cropped soybeans (R5, R5-G, and R5-D) enter the efficient set, respectively (Table 5). This is equivalent to only planting 518, 504, or 502 acres of double-cropped soybeans in rotation R1. Rotations R5-G and R5-D contain only 140 acres of double-cropped soybeans, whereas rotation R5 contains 200.

SUMMARY AND CONCLUSIONS

This study analyzes the economic returns and risk associated with crop rotations of wheat, soybeans, and grain sorghum, including double-cropping of soybeans following wheat harvest in southeastern Kansas. Six rotations (four of which include a sequence of wheat followed by double-cropped soybeans) are evaluated both with and without the option of participating in the government commodity program.

All rotations that include the double-crop sequence of wheat and soybeans without the government program have higher average net returns than crop rotations for farms in the government commodity program. When government program participation is included, net returns for rotations including higher acreages of double-cropping decline substantially more than returns for those that do not include the double-crop sequence. The reason for this is that the diversion of wheat land (set-aside acres) also reduces the acreage on which soybeans are double-cropped, therefore, substantially reducing expected gross income.

Stochastic dominance analysis indicates that when participation in the government commodity program is deemed essential, risk-averse managers would prefer a three-year rotation including grain sorghum followed by full-season soybeans followed by a sequence of wheat and double-cropped soybeans. If non-participation in the government program is also an option, then risk-averse managers would prefer the annual double-crop rotation of wheat followed by soybeans. The large amount of acreage that must be planted after wheat harvest without significant crop failures is an important factor in this result. Sensitivity analysis indicates that if labor or machinery constraints limit the number of acres of double-cropped soybeans and/or crop failure greater than that included in the data occurs, results would favor rotations that do not double-crop all acres each year.

REFERENCES

Cochran, Mark J., Lindon Robison, and Weldon Lodwick. "Improving the Efficiency of Stochastic Dominance Technique Using Convex Set Stochastic Dominance." Amer. J. Agr. Econ. 67(1985):289-95.

Doane's Agricultural Report. "Machinery Operating Costs, 1986." 49(1986).

Hexem, Roger W. and Robert F. Boxley. Trends in Double Cropping. Economic Research Service, Agricultural Economics Report No. 553, June 1986, pp. 6-8.

Kansas Farm Management Handbook. Dept. of Ag. Econ. and Coop. Ext. Service, Kansas State University, 1986.

King, Robert P., and Lindon J. Robison. "An Interval Approach to Measuring Decision Maker Preferences." Amer. J. Agr. Econ. 63(1981):510-20.

King, Robert P., and Lindon J. Robison. "Risk Efficiency Models." Risk Management in Agriculture. Iowa State University Press, Ames, Iowa. 1984. pp.68-81.

Lamond, Ray E., D. Leo Figurski, Larry C. Bonczkowski, and James P. Shroyer. "Double-cropping with Sunflowers." Ag Facts. Kansas State University Coop. Ext. Service, AF-127, January 1985, p. 1.

Langemeier, Larry N., and Leonard C. Parker. The Annual Report 1985: Management Information Kansas Farm Management Associations. Dept. of Ag. Econ. and Coop. Ext. Service, Kansas State University, 1986.

Langemeier, Larry N., Orlan H. Buller, and John L. Kasper. Labor Requirements for Eastern Kansas Crops. Kansas Ag. Exp. Sta. Bul. 587, June 1975.

Marra, Michelle C. and Gerald A. Carlson. Double-cropping Wheat and Soybeans in the Southeast: Input Use and Patterns of Adoption. Economic Research Service, Agricultural Economic Report Number 552, June 1986, pp. 3-4.

Parsch, Lucas D., Kalven L. Trice, Mark J. Cochran, and H. Don Scott. "Impact of wheat Harvest Timeliness on Risk Efficiency of Double-cropped Soybeans." Selected paper presented at AAEA Meeting, East Lansing, Michigan, August 2-5, 1987.

Pratt, J.W. "Risk Aversion in the Small and in the Large." Econometrica 32(1964):122-36.

Raskin, Robert, Sieu C.W. Goh, and Mark J. Cochran. A Stochastic Dominance with Respect to a Function Program for the IBM PC. Dept. of Agr. Econ. Staff Paper No. 2986, University of Arkansas, Jan. 1986.

Woodruff, John M., J. Earl Elsner, and William D. Givan. Double-cropping Soybeans in Georgia. Georgia Cooperative Ext. Service, Bul. 819, March 1981.

Table 1. Net Return Distributions - Without Government Program Participation.

Year	R1	R2	R3	R4	R5	R6
	Rotation					
1982	$152,049	$88,362	$72,438	$84,953	$76,379	$59,488
1983	134,889	82,182	62,990	78,547	60,870	43,169
1984	57,343	30,432	57,564	45,474	33,063	39,466
1985	37,784	44,687	(3,294)	16,560	53,595	30,536
1986	38,975	23,888	15,799	16,770	33,862	26,753
Mean	$84,208	$53,911	$41,099	$48,461	$51,554	$39,882
Std. Dev.	$54,986	$29,681	$32,952	$32,664	$18,454	$12,797
Coef. Var.	65.30	55.06	80.18	67.40	35.79	32.09
Minimum	$37,784	$23,888	($3,294)	$16,560	$33,063	$26,753
Maximum	$152,049	$88,362	$72,438	$84,953	$76,379	$59,488

R1: WDCSB
R2: WDCSB-FSSB
R3: W-W-FSSB
R4: W-WDCSB-FSSB
R5: SOR-FSSB-WDCSB
R6: SOR-FSSB-W

W - Wheat
DCSB - Double-crop Soybeans
FSSB - Full season Soybeans
SOR - Sorghum

Table 2. Government Commodity Program Parameters (1987).

Parameter	Wheat	Grain Sorghum[a]	Soybeans
Base Acres (typical S.E. Kansas Farm)	194	109	N/A
Acreage Reduction Requirement	27.5%	20.0%	N/A
Target Price	$4.38/bu.	$2.88/bu.	N/A
Statutory Loan Rate	$2.85/bu.	$2.28/bu.	N/A
Announced Loan Rate	$2.28/bu.	$1.74/bu.	$4.78/bu.
Optional Paid Land Diversion	N/A	15.0%	N/A
Optional Paid Land Diversion Rate	N/A	$1.90/bu.	N/A
Program Yield (Labette County, KS)	36 bu./acre	52 bu./acre	N/A

[a]The 109 acre feed grain base on the typical farm is all planted to grain sorghum.

Table 3. Net Return Distributions - With Government Program Participation and Optional Sorghum Diversion.

	Rotation							
Year	R1-G	R2-G	R3-G	R4-G	R5-G	R6-G	R5-D	R6-D
1982	$65,705	$61,843	$53,669	$54,801	$65,817	$53,972	$65,948	$54,134
1983	54,780	55,647	42,678	48,396	52,955	40,540	54,012	41,629
1984	20,065	17,875	29,427	19,843	30,163	34,699	30,500	35,068
1985	50,943	51,292	36,847	42,404	55,523	39,340	54,717	38,566
1986	24,863	20,101	22,749	17,102	36,312	30,653	35,344	29,717
Mean	$43,271	$41,352	$37,074	$36,509	$48,154	$39,841	$48,104	$39,823
Std. Dev	$19,824	$20,771	$11,943	$17,066	$14,605	$ 8,822	$14,746	$ 9,143
Coef. Var	45.81	50.23	32.21	46.75	30.33	22.14	30.65	22.96
Minimum	$20,065	$17,875	$22,749	$17,102	$30,163	$30,653	$30,500	$29,717
Maximum	$65,705	$61,843	$53,669	$54,801	$65,817	$53,972	$65,948	$54,134

R1: WDCSB
R2: WDCSB-FSSB
R3: W-W-FSSB
R4: W-WDCSB-FSSB
R5: SOR-FSSB-WDCSB
R6: SOR-FSSB-W

W - Wheat
DCSB - Double-crop Soybeans
FSSB - Full season Soybeans
SOR - Sorghum

-G - Basic Government Program
-D - Government Program with Paid Land Diversion for Sorghum

Table 4. Stochastic Dominance Analysis Results for Alternative Scenarios.

	Lower R(x)	Upper R(x)	Non-Participation Government Commodity Program	Participation Government Commodity Program	Participation in Government Commodity Program Including Paid Land Diversion	All Distributions With and Without The Government Program Including Land Diversion
FSD	-∞	+∞	R1	R2-G	R2-G	
			R3	R5-G	R5-G	
				R6-G	R5-D	R1
					R6-G	R3
SSD	0.0	+∞	R1	R5-G	R5-G	R1
				R6-G	R5-D	
					R6-G	
SDWRF						
	-0.00005 to	-0.00001	R1	R5-G	R5-G, R5-D	R1
	-0.00001 to	0.0	R1	R5-G	R5-G	R1
	0.0 to	0.00001	R1	R5-G	R5-G	R1
	0.00001 to	0.00005	R1	R5-G	R5-G	R1
	0.00005 to	0.0001	R1	R5-G	R5-G	R1

R1: WDCSB
R2: WDCSB-FSSB
R3: W-W-FSSB
R4: W-WDCSB-FSSB
R5: SOR-FSSB-WDCSB
R6: SOR-FSSB-W

W - Wheat
DCSB - Double-crop Soybeans
FSSB - Full season Soybeans
SOR - Sorghum

-G - Basic Government Program
-D - Government Program with Paid Land Diversion for Sorghum

Table 5. Sensitivity Analysis of SDRF Results.

Dominant Rotation	Compared Rotation[a]	Decrease in Net Return of Dominant Rotation[b]	Bushels Per Acre DCSB[c]	Minimum Acres of DCSB[d]
No Government Commodity Program Participation				
R1	R2	$11,612	---	416
R1	R3	31,677	9.2	97
R1	R4	20,461	---	275
R1	R5	5,190	---	518
R1	R6	11,825	3.4	412
Government Commodity Program Participation				
R5-G	R1-G	$ 8,205	---	<0
R5-G	R2-G	10,594	---	<0
R5-G	R3-G	8,437	10.3	<0
R5-G	R4-G	13,138	---	<0
R5-G	R6-G	3,295	4.0	84
R5-G	R5-D	5,703	---	---
R5-G	R6-D	3,557	4.4	79
With and Without Commodity Program Participation				
R1	R2	$11,612	---	416
R1	R3	31,677	9.2	97
R1	R4	20,461	---	275
R1	R5	5,190	---	518
R1	R6	11,825	3.4	412
R1	R1-G	15,567	---	353
R1	R2-G	18,089	---	313
R1	R3-G	14,652	4.2	369
R1	R4-G	20,030	---	282
R1	R5-G	6,030	---	504
R1	R6-G	9,439	2.7	450
R1	R5-D	6,181	---	502
R1	R6-D	9,700	2.8	446

[a]For identification of cropping systems, please refer to Table 4.

[b]The decrease in net return is the magnitude of the parallel shift of the dominant distribution (rotation) that is necessary to eliminate its dominance over the indicated rotation.

[c]The decrease in bushels per acres is the amount of yield decrease in the dominant distribution that is necessary to eliminate its dominance over the indicated rotation. In the case of the R1 and R5-G rotations, it is the indicated decrease in soybean yield given an average price of $5.75/bu. when not participating in the commodity loan program. The price used is $5.80/bu. when participating in the commodity loan program. These decreases are only listed when the dominant rotation is compared with rotations that do not include double-cropped soybeans.

[d]The minimum number of acres of double-crop soybeans that would have to be planted each year for the dominant rotation to remain dominant to the indicated rotation.

ENDNOTES

1. In Southeast Kansas, residual fertilizer from wheat is typically utilized by soybeans.

2. Farmers typically rent a fertilizer buggy to apply fertilizer. This operation is not listed in Doane's Agricultural Report. Rent for the buggy was estimated at $2.50 per acre, and field time was based on coverage of 15 acres/hr.

3. Rotations are used in southeast Kansas to break up the weed cycle. If continuous single-cropping is used, then soybean yields can be expected to decrease by approximately 10%.