Working Paper WP96-4 **November 1996**

Fifth Joint Conference on

Agriculture, Food and the Environment

Proceedings of a Conference Sponsored by
University of Minnesota
Center for International Food and Agricultural Policy

Universita degli Studi di Padova
Dipartimento Territorio e Sistemi Agro-forestali

Agricultural Development Agency – Veneto Region

University of Perugia

University of Bologna – CNR

SESSION III: AGRICULTURAL SYSTEMS WITH LOW ENVIRONMENTAL IMPACT

PAPER 3: RISKS AND RETURNS IN THE TRANSITION FROM HIGH TO LOW CHEMICAL CROPPING SYSTEMS

Kent D. Olson, David R. Huggins, Paul M. Porter, Catherine A. Perillo, and R. Kent Crookston

---

Center for International Food and Agricultural Policy

University of Minnesota
1994 Buford Avenue, 332 C.O.B.
St. Paul, Minnesota 55108-6040 U.S.A.
Phone: (612) 625-8713
FAX: (612) 625-6245

Working Paper WP96-4 November 1996

Fifth Joint Conference on

Agriculture, Food, and the Environment

Proceedings of a Conference Sponsored by

University of Minnesota
Center for International Food and Agricultural Policy

Università degli Studi di Padova
Dipartimento Territorio e Sistemi Agro-forestali

Agricultural Development Agency - Veneto Region

University of Perugia

University of Bologna - CNR

Abano Terme - Padova, Italy
June 17-18, 1996

Information on other titles in this series may be obtained from Waite Library, University of Minnesota, Department of Applied Economics, 1994 buford Avenue, 232 COB, St. Paul, MN 55108-6040, U.S.A.

RISKS AND RETURNS IN THE TRANSITION FROM HIGH TO LOW CHEMICAL CROPPING SYSTEMS[1]

Kent D. Olson, David R. Huggins, Paul M. Porter,
Catherine A. Perillo, and R. Kent Crookston[2]

Most, if not all farmers (and people) have multiple goals which they strive to optimize, or at least satisfy, in their personal and business lives. In the case of farmers, the traditional list of goals has included income level, risk reduction, net worth accumulation, leisure time, raising cattle, having the highest yield, etc. Another goal of farmers, which is mentioned ever more often, involves their concern for the environment. This goal is stated in various ways: conserving the soil; protecting the environment; improving the environment; farming with sustainable methods, using fewer chemicals, etc.

This goal or concern for the environment is causing many farmers to consider new production methods ranging from small changes in their current system to the replacement of one whole production strategy with another. However, estimating, a priori, how farmers will rank environmental goals relative to their other, traditional goals of income, wealth, risk, etc. is difficult. The choice of production strategy is not made by focusing on one goal to the ignorance of the others; it is a multi-goal situation. While income levels and risks obviously do affect a farmer's choice of production method, individual farmers may rank these goals differently from their neighbors. Another complication of understanding farmers' choices is that their ranking of goals may change over time as conditions change.

The objective of this paper is to improve our knowledge of how the traditional goals of income and risk reduction may affect farmers' choice of production methods especially those that are more environmentally sensitive. The distribution of net cash flows for alternative crop production methods or strategies were estimated. These distributions were compared to predict whether the traditional goals of income level and risk avoidance will be at odds with environmental goals or whether farmers can find production strategies that support both types of goals.

---

[1]Presented at the 5th Joint Conference on Agriculture, Food and the Environment, June 17-18, 1996, in Padova, Italy.

[2]Olson is Associate Professor, Department of Applied Economics; Huggins is Assistant Professor, Porter is Assistant Professor, and Perillo is Assistant Scientist, Southwest Experiment Station; and Crookston is Professor and Head, Department of Agronomy and Plant Genetics, all at the University of Minnesota.

Previous studies have used average yields and conditions to find that alternative tillage systems have lower costs than conventional systems (e.g., Smolik, Dobbs, and Rickerl; Weersink et al.). Salin, Dobbins, and Preckel estimated the distribution of net returns of different tillage systems but used only yield variation with no correlations. This paper extends their work by incorporating price variation and correlations between yields and prices.

This study uses the data from the initial years of a long-term, systems study in southwestern Minnesota. Even though the concept of sustainability in crop production involves a long-term, systems view of the use of natural resources, most studies have focused on single crop or single treatment effects. To address this lack of long-term, systems comparisons, two such studies were initiated near Lamberton in southwestern Minnesota in 1989: the Minnesota variable input crop management systems trials (VICMS I and II). Similar studies have begun in Wisconsin (Posner et al., 1995) and Italy (Giupponi, Olson, and Rosato, 1993). The emphasis of this paper is on whole systems analysis of the economic consequences of the transition to different production strategies. Agronomic consequences of the different production strategies are discussed in a forthcoming article.

METHOD

The specific objective of this paper was to compare the distribution of net cash flows for different management strategies in the early years of the VICMS trials. These distributions were estimated using the Agricultural Risk Management Simulator (ARMS; King et al., 1989). Given the average, standard deviation, and correlations for each yield and price distribution, ARMS estimated 250 potential sets of related yields and prices for each crop and strategy. The NCF for each strategy was calculated from yield and price information, the preharvest costs, the harvest costs (which varied with yield level), the number of acres of each crop, and the overhead cost for the whole farm. The overhead cost included cash costs such as family living and debt repayment that were not included in the crop production costs. These 250 estimated NCFs were sorted from lowest to highest to develop the cumulative distribution of NCF for each strategy.

The distributions of the NCFs were compared first for the highest average NCF, the lowest standard deviation, and the NCF at the 50th percentile. The distributions were also evaluated for downside risk by comparing NCFs at low percentile levels (e.g., 5%). The percentile at which the NCF was $0 was also noted and used for comparison.

DATA

The yield and field operation data were taken from the VICMS experiments in Southwestern Minnesota. In this area of Minnesota, crop production began in the 1870s with wheat grown almost exclusively. From the 1900s until the 1960s, corn, small grains, and pasture predominated. Since the 1960s, this region has been farmed almost exclusively with corn and soybean. Currently, corn and soybean currently are grown on more than 90% of the cropped land (Minnesota Agricultural Statistics Service, 1996).

The two sites for these trials were within 0.15 kilometers of each other on similar dark colored Mollisol soils developed from calcareous glacial till. Fertilizer and pesticide inputs have been quite different since 1959, the year the University of Minnesota established the Southwest Experiment Station (SWES). The VICMS II site has been cropped according to University recommendations since 1959 resulting in high soil fertility levels and low weed populations. By contrast, the VICMS I site was managed without fertilizer or pesticide inputs, resulting in soils with low fertility levels and high weed pressure. Since the common soil condition in this part of Minnesota was high fertility and low weed pressure, VICMS II was important for producers interested in the transition from conventional practices to low-purchased inputs or organic practices.

Two crop rotations and four management strategies were evaluated from a systems viewpoint rather than just yields of single crops as a function of different levels of inputs. The two crop rotations included a two-year corn/soybean rotation and a four-year corn/soybean/oat/alfalfa rotation. Each crop of each rotation was grown each year with the treatments randomized in a complete block design and three replicates of each. The four management strategies were arranged as subplots of the crop rotation plots and included minimal inputs (MI), low-purchased inputs (LI), high-purchased inputs (HI), and organic inputs (OI; Table 1). Each of these strategies was managed independently of the others.

Average crop yields and the standard deviations were calculated separately for each crop rotation, management strategy, and VICMS site using the plot yields from each year (Table 2). Correlations between crops also were calculated from the individual plot yield data for both VICMS I and II (Table 3 and 4, respectively).

The average of annual estimates of the costs of production were used as representative costs of production in ARMS (Table 5). Production costs were estimated for each year using actual cultural operations and equipment used as listed in the field records. The cost of each operation was taken from a survey of machinery costs that included fuel, maintenance, repairs, labor and overhead costs (Fuller et al., 1992). Market prices for the 1989-1992 period were used for inputs except for herbicides that were taken from Durgan et al. (1992). Average product prices, standard deviations, and correlations were estimated from the average monthly prices in Minnesota from 1989 through 1992 (Table 6).

Yield and price correlations were assumed to be zero since southwestern Minnesota was at the northern edge of the U.S. Corn Belt and, thus, does not have a significant impact on the grain market. The correlation between the alfalfa yield and price also was assumed to be zero for this study; although, since the local market plays a larger role in the discovery of the price of alfalfa hay than it does in the price of corn, the hay price and yield may have a weak negative correlation. If this were true, the income for the 4-year cropping rotations would have a higher average distribution with a lower standard deviation than that calculated with a zero correlation.

To estimate the impact of these management strategies at a farm level, an example farm of 600 crop acres was chosen as representative of southwestern Minnesota (Olson et al., 1992). This acreage included both owned and rented acreage. Neither opportunity costs for unpaid labor nor other cash costs, such as debt repayment, were included in the costs of crop production. Other cash obligations not counted in the crop production costs were set at $70,000 (Olson et al., 1992). ARMS used this estimate of other cash obligations to estimate the NCF for the example farm.

RESULTS

Using the information on yield and price distributions, the costs of production, and other costs, ARMS calculated 250 possible NCFs for each management strategy and crop rotation on the example farm. With these 250 estimated NCFs, the resulting distribution and cumulative probability of NCFs were developed.

For the HI management strategy on the 2-year crop rotation at the VICMS I site, the lowest possible net cash flow is estimated to be $-20,430 (Table 7). That is, if both yields and prices would happen to be at their lowest levels, the farm would suffer a loss of $20,430. If the best combination of yields and prices were to occur, ARMS estimated a net cash flow of $68,626 for the example farm. In other words, for the HI strategy and 2-year rotation on VICMS I, there is a 0% chance that the NCF will be lower than $-20,430 and a 100% chance that the NCF will be equal to or lower than $68,626. ARMS also estimates a 5% chance that NCF will be equal to or less that $579. Thus, the chance of a negative NCF is less than 5%; conversely, there is greater than a 95% chance of a positive NCF. For the HI strategy and the 2-year rotation at VICMS I, the average NCF for all 250 estimates is $25,100; the standard deviation is $16,209.

Graphically, these estimates result in an "elongated-S" for the cumulative probability (Figure 1). The estimated cumulative probability curve for the HI management strategy on the 2-year crop rotation at the VICMS I site is the darker solid line in the lower-left graph. It starts with a 0% probability that the example farm will have an NCF less than $-20,430 and ends with a 100% probability that the NCF will be equal to or less than $68,626.

Preferences between options can be made by evaluating the absolute level and relative riskiness of the NCF. Most farmers will prefer a strategy and rotation with the highest NCF at a 0% probability; this is HI, 2-year at VICMS I. Most farmers also prefer a smaller chance of negative NCF and would choose a combination of strategy and rotation that has the lowest % chance of an NCF of $0 or less; this usually requires some interpolation between percentiles.

At VICMS I, the HI strategy and 2-year rotation has the lowest percentile that has a positive NCF. At the 50% level, the HI strategy and 2-year rotation has the highest NCF. At the VICMS I site, the average NCF is highest for the HI, 2-year strategy. The standard deviation of the NCF is also lowest for the HI, 2-year strategy. The only measure in which the HI strategy and 2-year rotation does not rank first is the maximum NCF; at the VICMS I site, the HI strategy and the 4-year rotation have a 100% chance that the NCF will be equal to or less than $201,781. The HI strategy, 2-year rotation has a 100% chance that the NCF will be equal to or less than $68,626 -- the second lowest maximum NCF at the VICMS I site.

A similar set of comparisons can be made graphically. Usually, a strategy is preferred if it provides a greater NCF at a given cumulative probability level or if, for a specified NCF, it has a lower probability of being equal to or less than that NCF. Graphically, these preferences can be seen easily if the cumulative probability curve of one strategy lies to the right of other strategies. If it lies to the right at all levels, a strategy dominates the other strategies; this is described as first degree stochastic dominance. At the VICMS I site, the HI, 2-year strategy lies to the right of the other strategies until a cumulative probability level higher than 60% (Figure 1). Thus, the HI, 2-year strategy is preferred to other strategies and rotations up to that point, but it does not dominate the other strategies and rotations in terms of first degree stochastic dominance.[3]

Using these methods of comparisons, it appears that most farmers would choose the HI strategy and 2-year rotation over the other strategies and rotations. Even though the NCF for other strategies and rotations were greater at high levels of cumulative probability, the HI strategy and 2-year rotation had the highest average NCF, the lowest standard deviation, and higher levels of NCF at low levels of probability. Since most farmers are risk averse and more concerned with downside risk (i.e., low and negative NCF) than with upside risk (i.e., high NCF), the HI strategy and 2-year would be the clear preference for most farms when the soil started from a low fertility and high weed base level (VICMS I).

When the four management strategies and rotations were started on soil that has higher fertility and lower weed problems (VICMS II), the HI strategy and 2-year rotation also had the highest average net cash flow, lowest standard deviation, smallest percentage with negative returns, and highest net cash flow at the 50th percentile (Table 8). Comparing only the 4-year rotations, the MI and OI strategies had higher average NCFs and lower standard deviations than the HI strategy. However, while it did not dominate in terms of first-degree dominance,

---

[3]If the cumulative probability curves cross each other, a strategy can dominate for risk averse decision makers in terms of second degree stochastic dominance if the area under the cumulative distribution function of this strategy never exceeds and some where is less than the area under the cumulative distribution function of another strategy (Boehlje and Eidman, 1984, p. 467).

the HI, 2-year strategy lies to the right of the other choices at most probability levels (Figure 2).

CONCLUDING REMARKS

This paper evaluated the risks and returns of the transition of farms from different production strategies. The data were from the initial years of this long-term experiment and, thus, show the transitional phase of rotation and management strategy establishment. While we cannot make solid conclusions from these initial years about the future performance of these strategies and rotations, we can make the following observations.

On both VICMS I and VICMS II sites, the HI strategy in the 2-year crop rotation had the highest returns and lowest risk, as measured by the average NCF and standard deviation of the NCF. For the HI and LI strategies, the 2-year rotation had higher average NCFs than the 4-year rotation. Overall, the HI strategy and 2-year rotation had the highest average NCF, lowest standard deviation, and higher levels of NCF at low levels of probability. Since the NCF for other strategies and rotations were greater at high levels of cumulative probability, the HI, 2-year strategy did not dominate in terms of first degree dominance. However, since most farmers are risk averse and more concerned with downside risk (i.e., low and negative NCF) than with upside risk (i.e., high NCF), the HI strategy and 2-year would be the clear preference for most farms. While some strategies had higher NCFs at higher probability levels, the common concern about downside risk would be expected to swing farmers toward the HI strategy.

When the soil started from a high fertility and low weed base level (VICMS II), all strategies and rotations had higher NCFs compared with the NCFs of soils starting from a low fertility and high weed base level (VICMS I). This was especially evident for the MI and OI strategies in terms of the greater distance between the cumulative probability curves at the VICMS I site compared with the VICMS II site (Figure 1). Since it may be due to the carryover effect of previous chemical applications, this relative competitiveness of the MI and OI strategies at VICMS II may decrease as the carryover effect decreases. However, since the soil may take longer to become adapted to the OI strategy, the low competitiveness of the OI strategy at the VICMS I site may not be an accurate representation of the future.

Not all farmers should be expected to choose the HI strategy and the 2-year rotation, however. Farmers may decide in the evaluation of their multiple goals that other strategies, say LI, would satisfy their income and risk goals when balanced with LI's ability to satisfy an environmental goal also. Other enterprises on the farm, say dairy, may also cause a farmer to choose a 4-year rotation to provide forage for the livestock.

While these findings do not bode well for a widespread shift to longer crop rotations and lower chemical use due to the cost in both the absolute level of income and the variation in income, the future may look different. Some strategies (LI, for example) did not dominate, but were, shall we say, "close." Thus, as we learn more about how to manage the different crop production strategies and the average NCF improves and the variation in NCF decreases, an alternative strategy may rise in preference to the HI strategy. This also could happen if older, currently cheaper pesticides are removed from the market and not available for the HI strategy. However, in the mean time, the results show why many farmers in southwestern Minnesota remain with the 2-year rotation of corn and soybean and a high-purchased input strategy.

This evident preference by farmers for the HI strategy and the 2-year rotation of corn and soybean can be seen by observing current cropping patterns and practices in Southwestern Minnesota (Minnesota Agricultural Statistics Service, 1996). This preference sheds some light on how the farmers rank their multiple goals. That is, it appears that most farmers are choosing the strategy and rotation by placing a greater weight on economic goals (such as, risk reduction, income level) than on environmental goals (such as, lower chemical use, longer rotations). If, however, the choice of cropping patterns and practices is observed more closely, farmers can be seen moving away from traditional methods toward new methods that can be called more environmentally friendly. The move away from the moldboard plow, the increasing use of no-till methods, and the adoption of practices that require lower chemical use are three examples of farmers searching out ways to balance their environmental goals with their economic goals.

Table 1. General descriptions of the four management strategies: minimal inputs (MI), low-purchased inputs (LI), high-purchased inputs (HI), and organic inputs (OI).[4]

	----- MI -----	----- LI -----	----- HI -----	----- OI -----
Practice		----- corn -----		
Prior fall tillage	moldboard	none	chisel	chisel
Spring tillage	field cul (2x)	field cul (2x)	field cul (2x)	field cul (2x)
Rotary hoeing	1-5x(as needed)	1-5x(as needed)	none	1-5x(as needed)
Row cultivation	1-3x	1-3x	1-3x	1-3x
Tillage after harvest	moldboard	soil saver	moldboard	moldboard
Herbicides	none	pre-e.& post	ppi & post	none
Fertilizer application	none	banded	broadcast	organic[5]
Practice		----- soybean -----		
Prior fall tillage	chisel	none	chisel	chisel
Spring tillage	field cul./disk	field cul./disk	field cul./disk	field cul./disk
Rotary hoeing	once or twice	once or twice	none	once or twice
Row cultivation	2 or 3 x	2 or 3 x	2 or 3 x	2 or 3 x
Tillage after harvest	none	none	none	none
Herbicides	none	pre	ppi	none
Fertilizer application	none	banded	broadcast	organic
Practice		----- oat -----		
Prior fall tillage	none	none	none	none
Spring tillage	field cul (1x)	field cul (1x)	field cul (1x)	field cul (1x)
Rotary hoeing	none	none	none	none
Row cultivation	none	none	none	none
Tillage after harvest	none	none	none	none
Herbicides	none	none	none	none
Fertilizer application	none	broadcast	broadcast	organic
Practice		----- alfalfa -----		
Prior fall tillage	moldboard	soil saver	moldboard	moldboard
Spring tillage	field cul (2x)	field cul (2x)	field cul (2x)	field cul (2x)
Rotary hoeing	none	none	none	none
Row cultivation	none	none	none	none
Tillage after harvest	moldboard	moldboard	moldboard	moldboard
Herbicides	none	none	none	none
Fertilizer application	none	broadcast	broadcast	organic

[4]Specific operations used each year may have been different.

[5]For the OI strategy, the fertilization was with fall-applied, composted beef manure for the 4-year rotation and spring-applied swine manure for the 2-year rotation.

Table 2. Crop Yield[6] Average, Standard Deviation (S.D.), and Coefficient of Variation (C.V.) for the Variable Input Crop Management Studies (VICMS) I and II near Lamberton, Minnesota, 1989-1992.

Management[7] Strategy	Crop	Average	S.D.	C.V.	Management Strategy	Crop	Average	S.D.	C.V.
VICMS I, 2-year rotation					VICMS II, 2-year rotation				
MI	Corn	57	20	35%	MI	Corn	109	46	42%
	Soybean	34	7.7	23%		Soybean	47	11	23%
LI	Corn	129	12	9%	LI	Corn	148	21	14%
	Soybean	39	5.1	13%		Soybean	41	9	23%
HI	Corn	151	7.0	5%	HI	Corn	15	14	9%
	Soybean	43	4.2	10%		Soybean	47	7.3	15%
OI	Corn	102	27	27%	OI	Corn	122	28	23%
	Soybean	33	10	31%		Soybean	44	14	33%
VICMS I, 4-year rotation					VICMS II, 4-year rotation				
MI	Corn	70	12	17%	MI	Corn	114	14	12%
	Soybean	33	5.2	16%		Soybean	46	6.4	14%
	Oat	60	24	40%		Oat	95	30	31%
	Alfalfa	3.2	1.4	45%		Alfalfa	4.5	0.9	20%
LI	Corn	129	12	10%	LI	Corn	144	14	10%
	Soybean	41	4.3	11%		Soybean	39	13	33%
	Oat	86	39	46%		Oat	90	28	32%
	Alfalfa	4.1	1.8	45%		Alfalfa	4.3	1.2	28%
HI	Corn	149	8.7	6%	HI	Corn	152	12	8%
	Soybean	43	4.5	11%		Soybean	47	8.1	17%
	Oat	88	32	37%		Oat	92	33	36%
	Alfalfa	4.5	2.0	44%		Alfalfa	4.3	1.3	30%
OI	Corn	89	24	27%	OI	Corn	115	12	11%
	Soybean	37	5.6	15%		Soybean	45	7.3	16%
	Oat	71	25	36%		Oat	95	32	33%
	Alfalfa	3.5	1.7	48%		Alfalfa	4.4	1.2	27%

[6]Units are bushels per acre for corn, soybean, and oat; tons per acre for alfalfa.

[7]Management strategies are: MI = minimum inputs, LI = low purchased inputs, HI = high purchased inputs, OI = organic inputs

Table 3. Calculated Yield Correlations in the Variable Input Crop Management Studies (VICMS) I near Lamberton, Minnesota, 1989-1992.

a. MI management strategy and 2 year crop rotation:

	Corn
Soybean	0.511

b. LI management strategy and 2 year crop rotation:

	Corn
Soybean	0.469

c. HI management strategy and 2 year crop rotation:

	Corn
Soybean	-0.356

d. OI management strategy and 2 year crop rotation:

	Corn
Soybean	-0.099

e. MI management strategy and 4 year crop rotation:

	Corn	Soybean	Oat	Alfalfa
Corn		-.477	-.809	.080
Soybean			.637	.436
Oat				.154
Alfalfa				

f. LI management strategy and 4 year crop rotation:

	Corn	Soybean	Oat	Alfalfa
Corn		.184	.461	.691
Soybean			.130	.175
Oat				-.300
Alfalfa				

g. HI management strategy and 4 year crop rotation:

	Corn	Soybean	Oat	Alfalfa
Corn		-.136	-.390	.204
Soybean			.632	.136
Oat				.696
Alfalfa				

h. OI management strategy and 4 year crop rotation:

	Corn	Soybean	Oat	Alfalfa
Corn		-.047	-.563	-.125
Soybean			-.592	-.153
Oat				.560
Alfalfa				

* Management strategies were MI = minimal input; LI = low purchased input; HI = high purchased input; and OI = organic input.

Table 4. Calculated Yield Correlations in the Variable Input Crop Management Studies (VICMS) II near Lamberton, Minnesota, 1989-1992.

a. MI management strategy and 2 year crop rotation:

	Corn
Soybean	0.664

b. LI management strategy and 2 year crop rotation:

	Corn
Soybean	0.319

c. HI management strategy and 2 year crop rotation:

	Corn
Soybean	-0.043

d. OI management strategy and 2 year crop rotation:

	Corn
Soybean	0.726

e. MI management strategy and 4 year crop rotation:

	Corn	Soybean	Oat	Alfalfa
Corn		.669	-.417	-.117
Soybean			-.682	.140
Oat				-.644
Alfalfa				

f. LI management strategy and 4 year crop rotation:

	Corn	Soybean	Oat	Alfalfa
Corn		-.252	-.094	.488
Soybean			.641	-.750
Oat				-.852
Alfalfa				

g. HI management strategy and 4 year crop rotation:

	Corn	Soybean	Oat	Alfalfa
Corn		-.055	-.245	.891
Soybean			-.830	-.014
Oat				-.401
Alfalfa				

h. OI management strategy and 4 year crop rotation:

	Corn	Soybean	Oat	Alfalfa
Corn		.563	-.494	-.121
Soybean			-.600	.030
Oat				-.532
Alfalfa				

* Management strategies were MI = minimal input; LI = low purchased input; HI = high purchased input; and OI = organic input.

Table 5. Estimated Crop Production Costs for the Variable Input Crop Management Studies (VICMS) I and II near Lamberton, Minnesota, Averages for 1989-1992.

Management*	Corn	Soybean	Oats**	Alfalfa
	($/acre)			
VICMS I				
<u>2-year crop rotation</u>				
MI	82	75		
LI	122	97		
HI	157	102		
OI	98	79		
<u>4-year crop rotation</u>				
MI	91	76	46	98
LI	126	98	85	143
HI	157	104	107	152
OI	103	77	67	93
VICMS II				
<u>2-year crop rotation</u>				
MI	85	75		
LI	114	84		
HI	143	85		
OI	96	77		
<u>4-year crop rotation</u>				
MI	94	77	53	103
LI	121	82	80	133
HI	134	81	90	147
OI	106	76	58	108

* Management strategies were MI = minimal input; LI = low purchased input; HI = high purchased input; and OI = organic input.

** The average value of baled oat straw was used to offset the production costs. For VICMS I, the average value was $36 per acre for the MI strategy; $37 for LI; $37 for HI; and $30 for OI. For VICMS II, the average value was $36 for MI; $38 for LI; $39 for HI; and $41 for OI.

Table 6. Crop Prices: Averages, Standard Deviations, and Correlations, Minnesota, 1989-1992.

	Corn ($/bu)	Soybean ($/bu)	Oats ($/bu)	Alfalfa Hay ($/ton)
Average	2.22	5.73	1.39	88.33
Standard Deviation	0.18	0.61	0.43	15.43

Correlation Coefficients

	Corn	Soybean	Oats	Alfalfa Hay
Corn		0.667	0.462	0.509
Soybean			0.829	0.769
Oats				0.759
Alfalfa Hay				

Source: Calculated from monthly prices for 1989-1992, Minnesota Agricultural Statistics 1994, p. 96-97.

Table 7. Estimated Net Cash Flow Cumulative Distributions for Variable Input Crop Management Studies (VICMS) I by rotation and strategy.

	VICMS I, 2-year crop rotation			
Percentile	MI*	LI	HI	OI
	($/farm)			
0	-89038	-25472	-20430	-65148
1	-73029	-17907	-12841	-53626
5	-59142	-8549	579	-37072
10	-52012	-2479	5582	-28299
25	-38190	8536	13658	-14578
40	-26713	15536	21041	-2398
50	-21082	19089	24206	2882
60	-16358	23056	29125	9316
75	-3850	30954	34981	20216
90	11260	43196	44906	32652
95	17110	50356	53196	41300
99	49603	61180	64996	58721
100	61717	88931	68626	87471
Mean	-20941	19918	25100	2717
Std.Dev.	24937	17816	16209	24585

	VICMS I, 4-year crop rotation			
Percentile	MI	LI	HI	OI
0	-62326	-66821	-56164	-54041
1	-51443	-48749	-48655	-49934
5	-44980	-35662	-31018	-39273
10	-39015	-27947	-23411	-28429
25	-27791	-4785	-6072	-12254
40	-15797	7709	8432	-1309
50	-11052	15714	16788	4560
60	146	21634	24895	11319
75	9330	34865	40691	25994
90	28014	61396	71200	44075
95	37450	80065	81511	49519
99	47775	92641	130144	84810
100	100387	117074	201781	133929
Mean	-7342	16141	20064	6631
Std.Dev.	25675	33067	37675	28526

* Management strategies were MI = minimal input; LI = low purchased input; HI = high purchased input; and OI = organic input.

Table 8. Estimated Net Cash Flow Cumulative Distributions for Variable Input Crop Management Studies (VICMS) II by rotation and strategy.

Percentile	MI*	VICMS II, 2-year crop rotation LI	HI	OI
		($/farm)		
0	-89482	-24024	-14484	-59559
1	-63588	-14755	-5443	-49415
5	-44046	-3241	11392	-24616
10	-22560	8842	18192	-12224
25	5621	23939	30360	11714
40	23030	35539	40270	27472
50	33784	39102	44330	37072
60	46062	45258	50012	45230
75	66034	57158	56933	62797
90	96903	73759	73029	86700
95	112018	81509	84026	105705
99	172697	100854	101554	129385
100	194121	138055	112698	188449
Mean	35684	40586	45479	37582
Std.Dev.	47750	25956	21572	39504

Percentile	MI	VICMS II, 4-year crop rotation LI	HI	OI
0	-26183	-25018	-35475	-23045
1	-17170	-19084	-25499	-10675
5	809	-8076	-9575	1952
10	8758	545	-421	6552
25	24915	11918	16838	20756
40	35116	22077	27334	29360
50	41991	27878	35720	35044
60	47740	33621	40073	43172
75	58200	42101	48606	55201
90	68570	57410	72610	68980
95	75527	65777	81571	77759
99	96883	78533	95687	97113
100	112038	91282	116951	107068
Mean	40687	28248	34248	37633
Std.Dev.	24069	22057	26980	24149

* Management strategies were MI = minimal input; LI = low purchased input; HI = high purchased input; and OI = organic input.

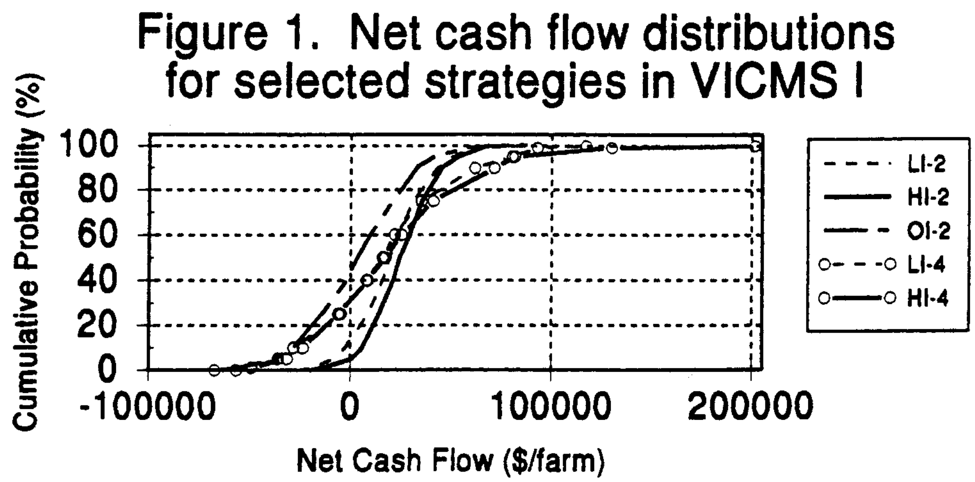
Figure 1. Net cash flow distributions for selected strategies in VICMS I
Cumulative Probability (%)
100
80
60
40
20
0
-100000
0
100000
200000
Net Cash Flow ($/farm)
LI-2
HI-2
OI-2
LI-4
HI-4

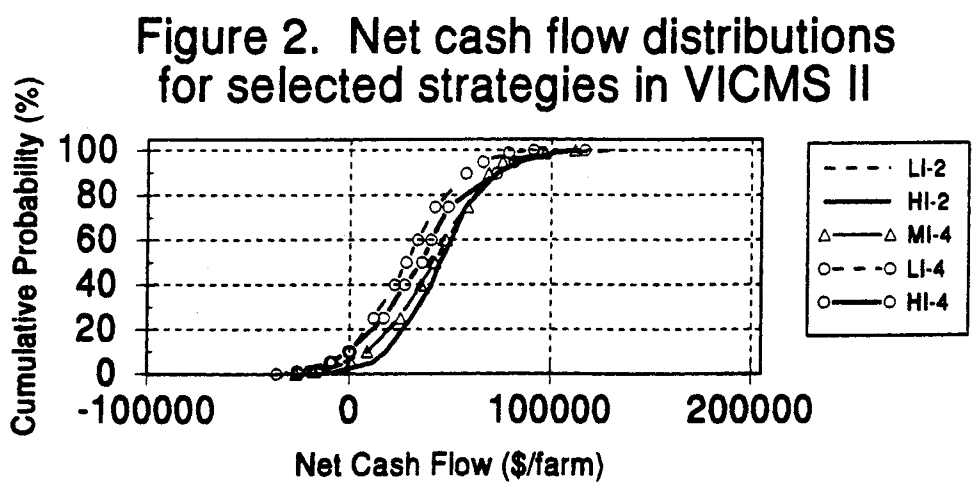
Figure 2. Net cash flow distributions for selected strategies in VICMS II
Cumulative Probability (%)
100
80
60
40
20
0
-100000
0
100000
200000
Net Cash Flow ($/farm)
LI-2
HI-2
MI-4
LI-4
HI-4

REFERENCES

Boehlje, M.D., and V.R. Eidman. 1984. Farm Management. New York: John Wiley & Sons.

Durgan, B.R., J.L. Gunsolus, R.L. Becker and A.G. Dexter. 1992. "Cultural and Chemical Weed Control in Field Crops--1992." AG-BU-3157-S, Minnesota Extension Service, University of Minnesota, St. Paul.

Giupponi, C., K. Olson, and P. Rosato. 1993. Current Research on Agricultural Systems with Different Input Strtegies and Environmental Impact Levels: Experiences in Veneto (Italy) and Minnesota (USA). In P.Rosato, ed., Agricultural Policy and Environment, Padova (Italy): Unipress s.a.s.

King, R.P., F.J. Benson, J.R. Black, and P.A. Held. 1989. Agricultural Risk Management Simulator. AG-CS-2577, Minnesota Extension Service, University of Minnesota.

Fuller E., B. Lazarus, L. Carrigan, and G. Green. 1992. "Minnesota Farm Machinery Economic Costs Estimates for 1992." AG-FO-2308-C, Minnesota Extension Service, University of Minnesota, St. Paul.

Minnesota Agricultural Statistics Service. 1996. Minnesota Agricultural Statistics. St. Paul, Minnesota.

Olson, K.D., E.J. Weness, D.E. Talley and P.A. Fales. 1992. "1991 Annual Report of the Southwestern Minnesota Farm Business Management Association." Economic Report ER92-3, Department of Agricultural and Applied Economics, University of Minnesota, St. Paul.

Posner, J.L., M.D. Casler, and J.O. Baldock. 1995. The Wisconsin integrated cropping systems trial: Combining agroecology with production agronomy. American Journal of Alternative Agriculture, 10:98-107.

Salin, V., C.L. Dobbins, and P.V. Preckel. 1995. Effects of soil conservation tillage on probability distributions of farm returns in Indiana. Selected paper at the American Agricultural Economics Association, Indianapolis, IN, August 6-9, 1995.

Smolik, J.D., T.L. Dobbs, and D.H. Rickerl. 1995. The relative sustainability of alternative, conventional, and reduced-till farming systems. American Journal of Alternative Agriculture, 10(1):25-35.

Weersink, A., M. Walker, C. Swanton, and J.E. Shaw. 1994. Costs of conventional and conservation tillage systems. Journal of Soil and Water Conservation, 47(4):328-334.