SARE Project LNC93-55

Profitability and Nitrate Leaching Effects of Possible Farming Practice and System Changes over South Dakota's Big Sioux Aquifer: Case Farm No. 1 Summary

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ECONOMICS DEPARTMENT

South Dakota State University
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CASE FARM NO. 1 SUMMARY

Introduction

The overall goal of the SARE/Water Quality project was to determine whether economic incentives offered by recent environmental provisions of the Federal farm program are sufficient to induce Western Corn Belt/Northern Great Plains farmers in environmentally sensitive areas to adopt sustainable farming practices and systems. To attain this goal, four case farms were chosen to be involved in this study based on their size, soil types, cropping systems, topography, and management in the Big Sioux Aquifer study area.

Description of the Case Farm

<u>Baseline System: Before</u>

Case Farm No. 1 is located in Brookings County and followed a corn-soybean-alfalfa rotation prior to enrollment in the Integrated Crop Management (ICM) program. It is a dryland operation that uses reduced tillage, consisting of mulch tillage of corn and minimum tillage on the soybeans. Alfalfa was clear-seeded with a Brillion drill. There was no harvest for the establishment year. On some acres, the alfalfa was rotated with corn and soybeans. After the establishment year, the alfalfa was harvested for 4 years before being broken up. The total operation consists of 1,283 acres, with 266 acres (in two tracts of land) under the ICM program being focused on in the study. The majority of the soils on the ICM land are a combination of coarse (Fordville), medium (Brandt), and fine-textured (Marysland) soils. All of these soils cover a shallow drinking water aquifer.

All machinery operations, inputs, etc. used in the baseline system were entered into a program called CARE (Cost and Return Estimator) to generate crop budgets. The figures from these crop budgets were compiled into an economics summary spreadsheet to show economic performance before ICM enrollment (Table 1). The first row shows the number of acres for each crop based on the rotation followed. The next line shows the yield for each crop. Net returns are calculated by subtracting operating costs, such as fertilizer, pesticide, fuel, labor, machinery, and other costs, from total receipts. The operating costs include such costs as depreciation, interest on machinery, and family labor (i.e., certain "fixed" costs). Case Farm No. 1 did not participate in the farm program and, therefore, it did not receive any deficiency payments.

<u>Baseline System: After</u>

The ICM program incorporates pest and nutrient management, crop selection and rotation, and conservation measures into a more comprehensive management program than is usually associated with Agricultural Conservation Program[1] cost share. Practices may include soil and tissue testing, field

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[1] The ICM is one of many different practices that are administered through the USDA's Agricultural Conservation Program (ACP).

scouting, cover crops, green manures, improved rotations, composting, and other techniques for reducing the use of agrichemicals.

Enrollment in the ICM program began in 1993 for Case Farm No. 1. Crop rotation and practices did not change after enrolling in the ICM program. However, there were some planned changes underway at the time that Case Farm No. 1 enrolled in the ICM program and those were included in both the baseline "before" and the baseline "after" scenarios. These changes included switching to no-till drilled beans. Case Farm No. 1 received cost-share to help pay for crop consulting. The total projected to be received each year in the program was $781, or $2,343 for the 3-year contract. Each year, this case farm is receiving $7/acre on a 111.6-acre tract of land enrolled in the ICM program. The farmer is receiving cost share for pesticide management and nutrient management practices. The cost-share from both of these practices can be used to pay for crop consulting. The cost-share and the crop consulting fees offset one another and neither is included on the economics summary spreadsheet. Practices that are being followed but not cost-shared are conservation cropping sequence, conservation tillage, and crop residue. If one divides the $781 annual payment by the total of 266 acres (in two tracts of land) under ICM, the cost reimbursement comes to approximately $3/acre. Since there was no change between "before" program participation and "after" program participation, the figures for the baseline "after" are the same as in Table 1.

Major Simulated Changes

Description of Practice Changes

In this study, we also performed profitability analyses for possible additional **practice** changes. These are "what if" scenarios that are not actually being used at this time, but that are likely management alternatives for this case farm. The key in Table 2 shows a complete list of the different alternatives analyzed for Case Farm No. 1.

The practice change for Case Farm No. 1 involved splitting the nitrogen application on corn into two operations (Alternative #4), with the first (lighter) application at planting and the second (heavier) application in the middle of June. Use of a nitrogen inhibitor, N-Serve, was also analyzed (Alternative #5), but is discussed more in a later section of this report.

Description of System Changes

Additional **systems** with slightly more diverse crop rotations were analyzed to compare economic and environmental results with the results from the baseline "before" and "after" scenarios. The diverse rotations include oats (as a nurse crop for alfalfa), alfalfa (harvested for 2 years after seeding), soybeans, and corn. In one rotation, soybeans are grown 2 years out of 6 and corn is only grown 1 year (Alternative #9); in the other, soybeans are grown 1 year and corn is grown 2 years (Alternative #10). Table 3 shows the yield estimates for the baseline and the alternative practices and systems under different climate scenarios.

Input Expenditure Summary Comparison

Input expenditure comparisons were made between the baseline systems and the alternatives with practice or system changes. These comparisons were categorized into fertilizer, pesticide, fuel, labor, machinery, and other (seed cost, trucking, etc.) expenses and were put into individual bar charts (Figures 1-6). The comparisons between the different alternatives are based on the "typical" year only. As expected, practice changes involved little change in the input expenditures, while changing to more diverse rotations caused a more dramatic change.

Some unexpected results did occur, however. Alternative #10 had the highest fertilizer cost of all the alternatives. Two things contributed to this unexpected result: 1) potassium and phosphorus were used to fertilize alfalfa, and 2) this rotation has two years of corn and one year of soybeans as opposed to one year of corn and two years of soybeans in Alternative #9. The inclusion of alfalfa to a greater degree in the diverse rotations (132 acres of alfalfa in Alternatives #9 and #10, counting the nurse crop year) led to higher machinery and labor cost for these systems, but it also dropped pesticide costs for these systems compared to the baseline system (80 acres of alfalfa).

Nitrate Leaching Comparisons

The nitrate leaching estimates were made using the computer model NLEAP (Nitrogen Leaching and Economic Analysis Package). This is a general model designed for use by land owners/operators/managers to help in deciding which farm management practices may impact groundwater quality (nitrates) under various rotations and cropping systems over several years of simulation.

Case Farm No. 1 had three soils each analyzed with different management alternatives (Table 2) pertinent to a given parcel of land. The "whole-farm" nitrate leaching is dependent upon how many acres of each soil were used in the analysis. As an example, if there were 10#/Ac of nitrate leached on 40 acres of a coarse-textured soil out of a 100 acre parcel, and 20#/Ac of nitrate leached on 60 acres of a fine-textured soil, the whole-farm nitrate leaching would be 16#/Ac ((10*40/100) + (20*60/100) = 16). **The nitrogen leaching amounts given in pounds/Ac (Figures 7-9) are whole-farm leaching annual averages.** The nitrogen leaching values should not be compared to those for the other case farms, since soils, crop practices and systems may be quite different. The nitrate leaching values can be used as indicators of what the magnitudes and variability of nitrate leaching might be on typical farms in the Big Sioux Aquifer area.

Profitability/N Leaching Results

Three different precipitation situations (typical, wet, and dry) were examined to see how the different alternatives would be affected economically and environmentally under different moisture conditions. The annual precipitation for the wet and dry years was what would be expected 10% of the time. These different conditions had varying effects on the economic and environmental results for the different alternatives. The three simulated climatic patterns were 6 average years, 6 wet years, and 6 dry years. The results were put into charts, with increased economic returns extending vertically up the left side of the chart and increased nitrogen leaching extending horizontally to the right along the bottom of the chart. Points were plotted for each alternative based on their economic and environmental results (stated in annual amounts), illustrating tradeoffs and complements for each precipitation situation (Figures 7-9).

In the "typical" year (Figure 7), profitability was slightly greater for splitting nitrogen application ($92.51/ac) when compared to the baseline scenario ($91.80/ac). The alternative systems had significantly greater economic returns ($109.26/ac for Alternative #9 and $106.15/ac for Alternative #10) than the baseline system and the alternative practice. Environmental results for splitting nitrogen application showed a slight decrease in the amount of nitrogen leached, dropping to 9 lbs/ac from 12 lbs/ac for the baseline system. However, the alternative systems showed an unexpected increase (15 lbs/ac for Alternative #9 and 14 lbs/ac for Alternative #10) in the amount of nitrogen leached. This may be attributed to the high amount of nitrogen leached for the oats/alfalfa component of the alternative rotations. Even though there is alfalfa in the baseline system, it is on fewer acres, so the contribution to the whole-farm nitrogen leaching figures is not as great as in the alternative systems.

In the "wet" year (Figure 8), the profitability rankings remained the same as in the "typical" year, except that the two alternative systems reversed rank ($154.11/ac for Alternative #9 and $157.31/ac for Alternative #10). The corn crop was more profitable than soybeans in the wet year, so the alternative system with 2 years of corn and 1 year of soybean was the most profitable. Environmental results showed that the baseline systems had the lowest level of nitrogen leaching (11 lbs/ac). Again, the high contribution of nitrogen leached associated with the alfalfa crop in the alternative systems is the explanation for this occurrence.

In the "dry" year (Figure 9), the profitability rankings were the same as the "typical" year. However, nitrogen leaching rankings changed, with the baseline systems having the highest level of nitrogen leaching (7 lbs/ac). This is probably due to the amount of nitrogen leaching for the alfalfa crop dropping significantly for the "dry" year, while the amount of nitrogen leaching for the corn in the baseline system increased.

The profitability figures for the "wet" and "dry" scenarios were affected by yield estimations based on how "wet" or "dry" conditions were assumed to affect different crops for each alternative on the different soils that were being dealt with on this case farm. Nitrogen leaching figures were determined by running the nitrogen leaching model with appropriate precipitation levels for the "wet" and "dry" scenarios.

Sensitivity Analyses

In addition to the simulated practice and system changes, some sensitivity analyses were done with alfalfa prices and yields. For these analyses, whole farm net returns were recorded for the baseline system and for the alternative systems which included alfalfa as alfalfa prices or alfalfa yields were decreased. The purpose of these analyses was to determine how sensitive the rankings of the different alternatives were to assumed alfalfa prices and yields.

Figure 10 shows how profitability for different systems changes as the alfalfa price decreases from $55.00/ton (price used in all systems) to $35/ton. Similarly, Figure 11 shows how profitability for the different systems changes as alfalfa yield decreases by 1/2 ton intervals. Prior to the sensitivity analyses, Alternative #9 had the highest profitability, followed by Alternative #10, Alternative #4, baseline, and Alternative #5. In order to change the profitability rankings for Case Farm No. 1, a decrease in price or yield greater than 35% would be required. This indicates that the profitability rankings are not very sensitive to alfalfa prices or yields. This may be attributed to the fact that the baseline system also used alfalfa as part of the rotation.

Selected Other "Practice" and/or "System" Changes

There was another alternative practice analyzed for this case farm, but it was not included in the results with the other changes because we were not sure how effectively it accomplishes what it is intended to do. This alternative, N-Serve (Alternative #5), involved a nitrogen inhibitor to slow the degradation of nitrogen. For all climate scenarios, the baseline had a slightly higher level of profitability than this alternative. This alternative had lower levels of nitrogen leaching than the baseline system, however, except for the "wet" year (11 lbs of nitrogen leached/acre for the baseline system vs. 12 lbs. of nitrogen leached/acre for Alternative #5).

Another analysis was performed for a system change. This analysis consisted of using a low-intensity crop, in this case sudan grass, on all acres to determine the amount of stewardship payment needed to make the low-intensity system equally profitable to the baseline. The result of switching all of the ICM acres on Case Farm No. 1 to sudan grass was a $115/acre drop in whole-farm profitability--from $91.80 to $-23.52. Consequently, this alternative system appears to have little chance of viability for voluntary, cost-shared adoption.

Methodological Notes

In some situations, we were unable to model both economic and environmental implications of an alternative. For Case Farm No. 1, there was not enough information to enable us to model the impact on nitrogen leaching of switching to a low-intensity crop (sudan grass). The analysis of that alternative is based solely on economic returns.

Table 1. CARE Budget Spreadsheet: Case Farm #1 - Before=After Program

	Corn	Soybeans	Alf est.	Alfalfa	Last alf	WHOLE FARM
Units	Bushels	Bushels	Tons	Tons	Tons	
Acres	93	93	16	48	16	266
Yield/ac	110	35	0	4	4	
Defc. Pmts./ac	$0.00	$0.00	$0.00	$0.00	$0.00	
Total Receipts ($/acre)	$220.00	$192.50	$0.00	$220.00	$220.00	
Operating Costs ($/acre)	$133.09	$79.74	$68.31	$109.77	$116.78	
Net Returns ($/acre)	$86.91	$112.76	($68.31)	$110.23	$103.22	
********* *********	*********	*********	*********	*********	*********	*********
Total Crop Returns ($/crop)	$8,082.63	$10,486.68	($1,092.96)	$5,291.04	$1,651.52	$24,418.91
					$/ac =	$91.80

Table 2. Baseline Systems and Other Possible Practice and Systems Changes, Case Farm No. 1

Key #	Alternative Description
1	Baseline (Before=After)
4	Splitting N app.
5	Using N-Serve
9	O/A,A,A,S,C,S rotation*
10	O/A,A,A,C,S,C rotation**

*-Oats/Alfalfa,Alfalfa,Alfalfa,Soybeans,Corn,Soybeans rotation
**-Oats/Alfalfa,Alfalfa,Alfalfa,Corn,Soybeans,Corn rotation

Table 3. Yield estimates for Various Management Practices with Different Climates for Case Farm #1.

System, field rotation and soils	Corn Yields in bu/ac			Soybean Yields in bu/ac			Alfalfa Yld, Tons/ac, 1stYr			Alfalfa Yields, Tons/ac			Oat Yields in bu/ac		
	Average	Dry	Wet	Average	Dry	Wet	Average	Dry	Wet	Average	Dry	Wet	Average	Dry	Wet
"Before" (baseline) = "After"															
Parcel A															
Brandt soil-C,S rotation	110	75	145	35	31	38									
Parcel B															
Fordville soil-A,C,S rotation	110	60	140	35	27	37	0	0	0	4	1.5	6			
Marysland soil-A,C,S rotation	110	90	100	35	33	32	0	0	0	4	2.5	7			
Splitting N applications															
Parcel A															
Brandt soil-C,S rotation	112	77	147	35	31	38									
Parcel B															
Fordville soil-A,C,S rotation	112	62	142	35	27	37	0	0	0	4	1.5	6			
Marysland soil-A,C,S rotation	112	92	102	35	33	32	0	0	0	4	2.5	7			
One Appl'n N w/N-inhibitor															
Parcel A															
Brandt soil-C,S rotation	112	77	147	35	31	38									
Parcel B															
Fordville soil-A,C,S rotation	112	62	142	35	27	37	0	0	0	4	1.5	6			
Marysland soil-A,C,S rotation	112	92	102	35	33	32	0	0	0	4	2.5	7			
O/A,A,A,S,C,S rotation															
Parcel A															
Brandt soil-O/A,A,A,S,C,S	120	85	155	35	31	38				4.5	2.5	7	75	60	55
Parcel B															
Fordville soil-O/A,A,A,S,C,S	120	70	150	35	27	37				4.5	2	6.5	75	55	60
Marysland soil-O/A,A,A,S,C,S	120	100	110	35	33	32				4.5	3	7	75	65	45
O/A,A,A,C,S,C rotation															
Parcel A															
Brandt soil-O/A,A,A,C,S,C	117	82	152	35	31	38				4.5	2.5	7	75	60	55
Parcel B															
Fordville soil-O/A,A,A,C,S,C	117	67	147	35	27	37				4.5	2	6.5	75	55	60
Marysland soil-O/A,A,A,C,S,C	117	97	107	35	33	32				4.5	3	7	75	65	45

Figure 1.

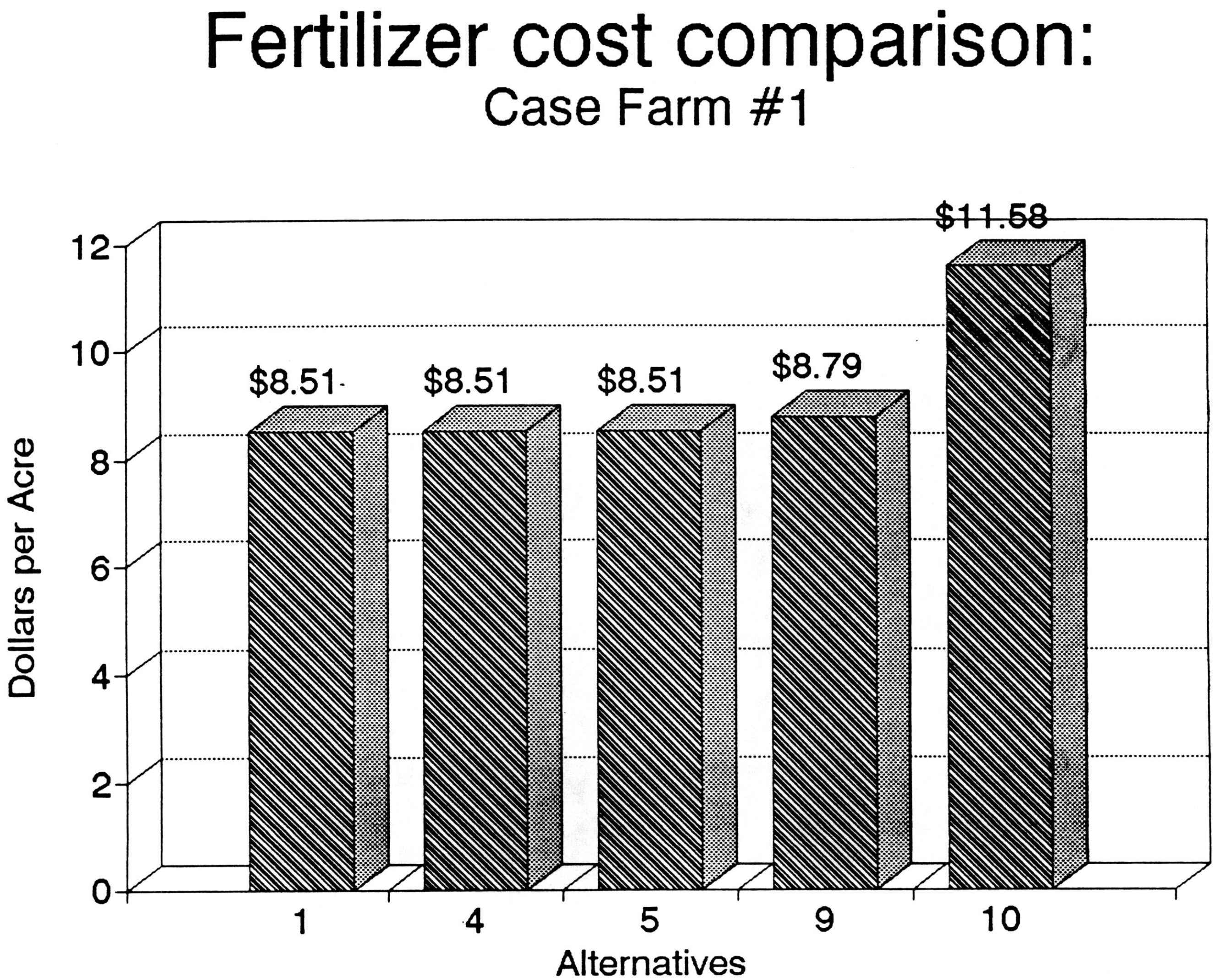

Fertilizer cost comparison:
Case Farm #1
Dollars per Acre
0
2
4
6
8
10
12
$8.51
$8.51
$8.51
$8.79
$11.58
1
4
5
9
10
Alternatives

Figure 2.

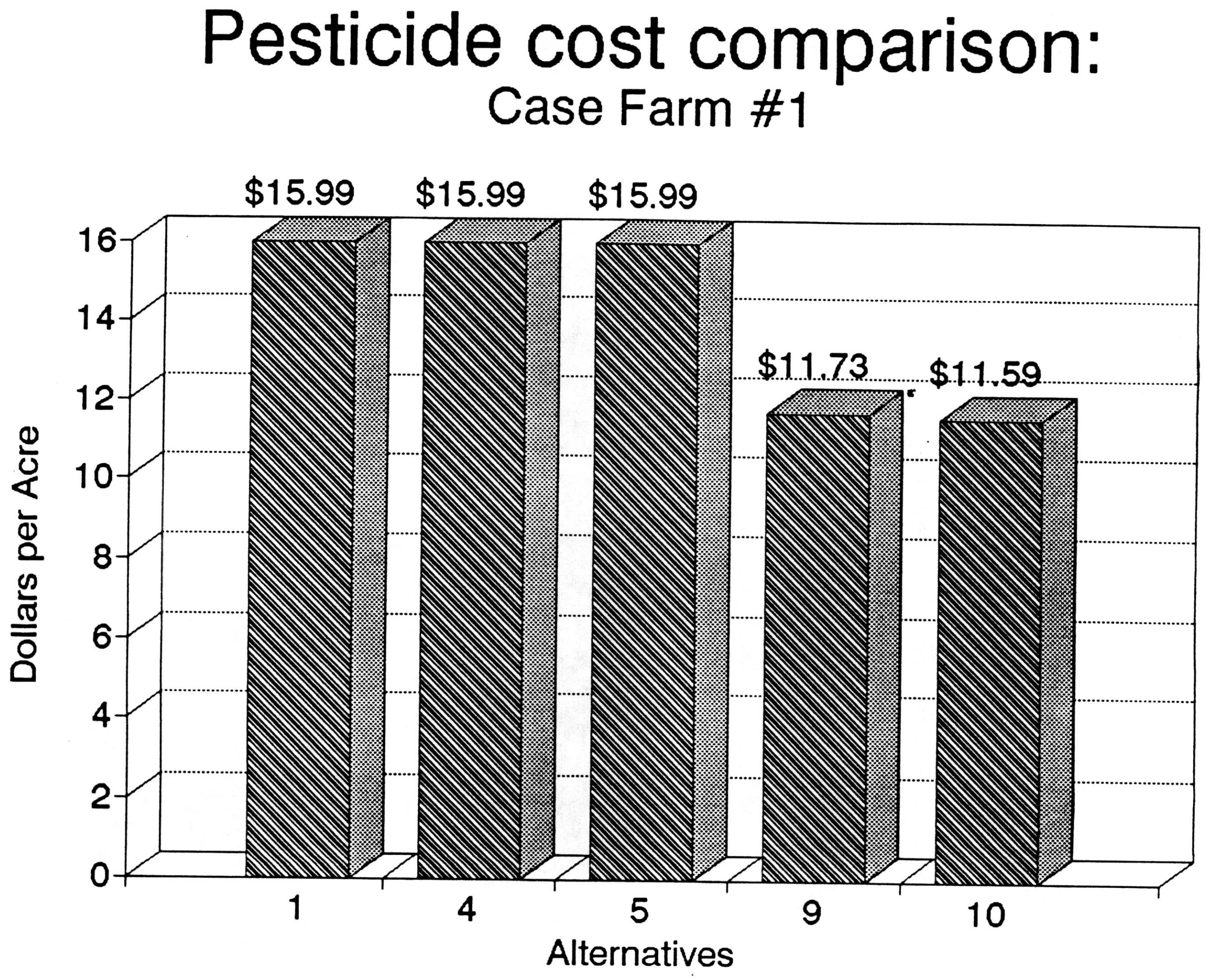
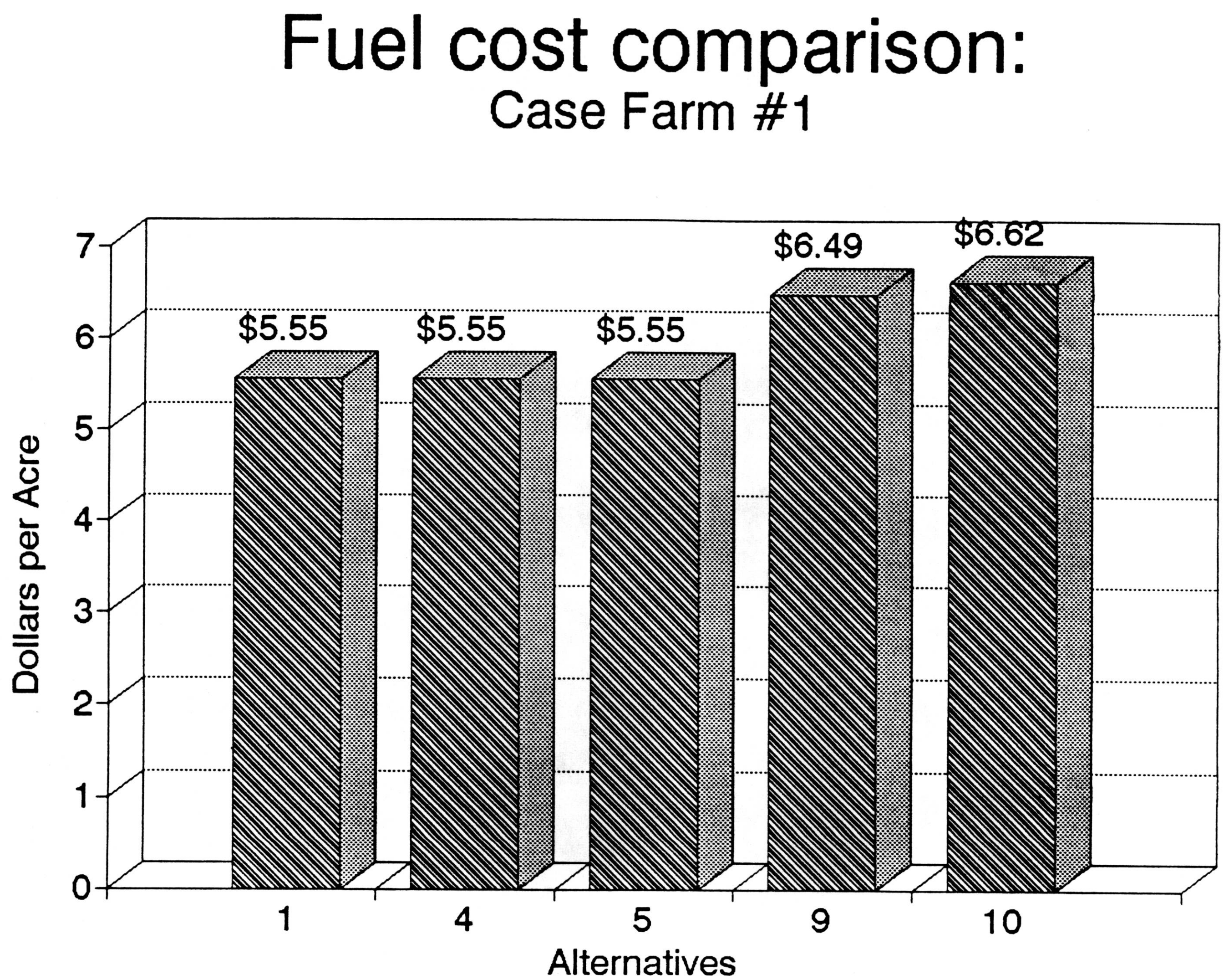

Pesticide cost comparison:
Case Farm #1
$15.99
$15.99
$15.99
$11.73
$11.59
16
14
12
10
8
6
4
2
0
Dollars per Acre
1
4
5
9
10
Alternatives

Figure 3.



Fuel cost comparison:
Case Farm #1
Dollars per Acre
0
1
2
3
4
5
6
7
$5.55
$5.55
$5.55
$6.49
$6.62
1
4
5
9
10
Alternatives

Figure 4.

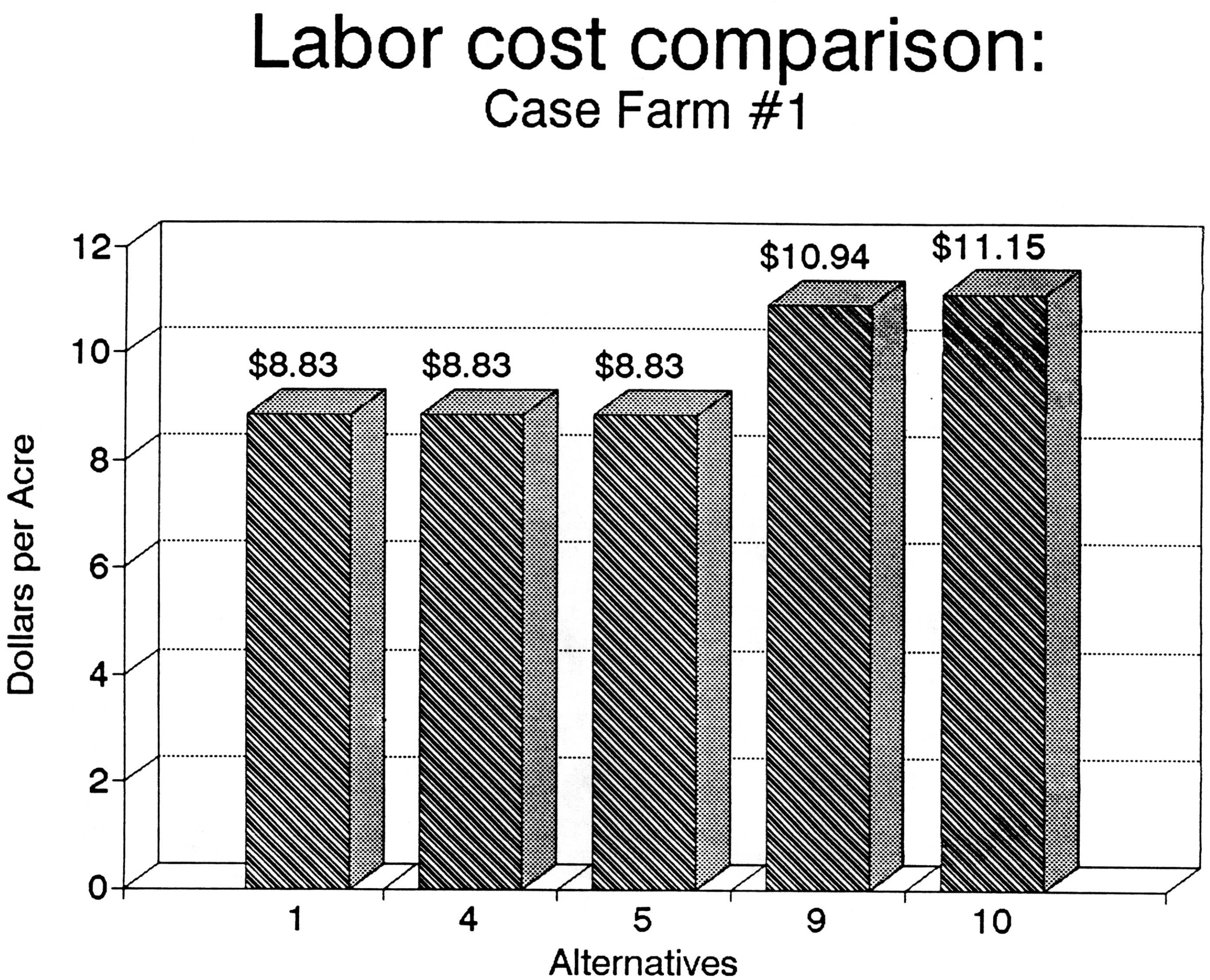
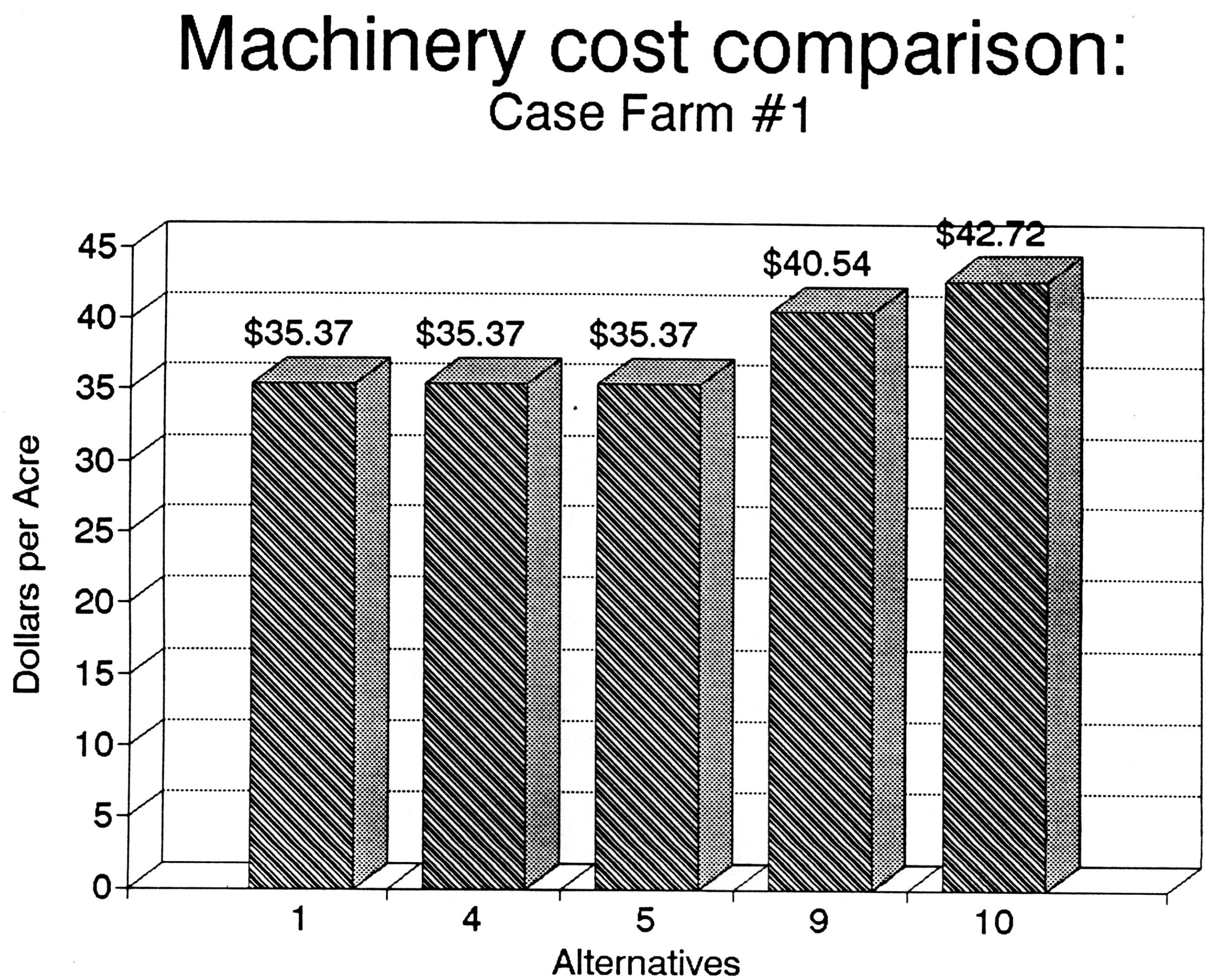
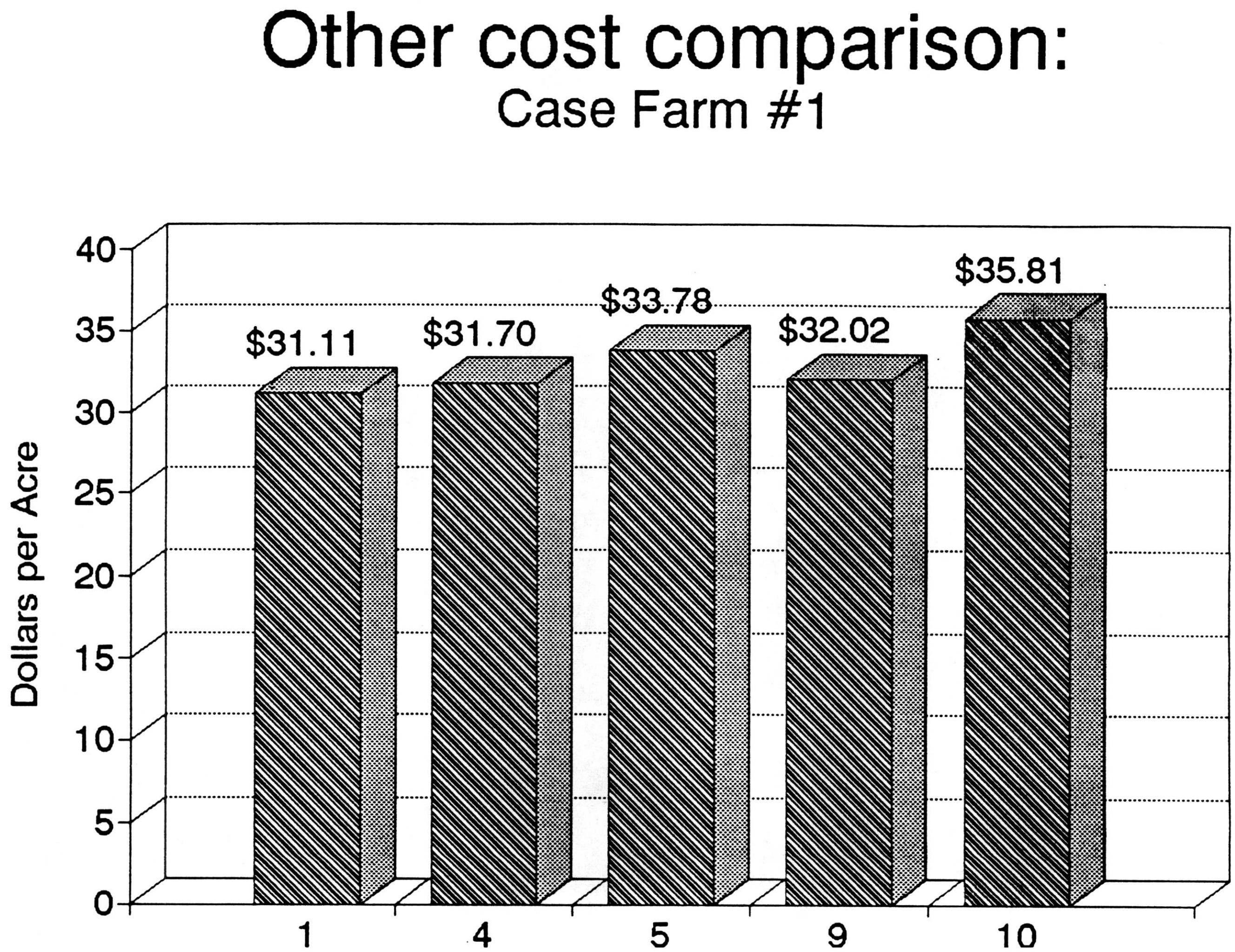

Labor cost comparison:
Case Farm #1
Dollars per Acre
0
2
4
6
8
10
12
$8.83
$8.83
$8.83
$10.94
$11.15
1
4
5
9
10
Alternatives

Figure 5.



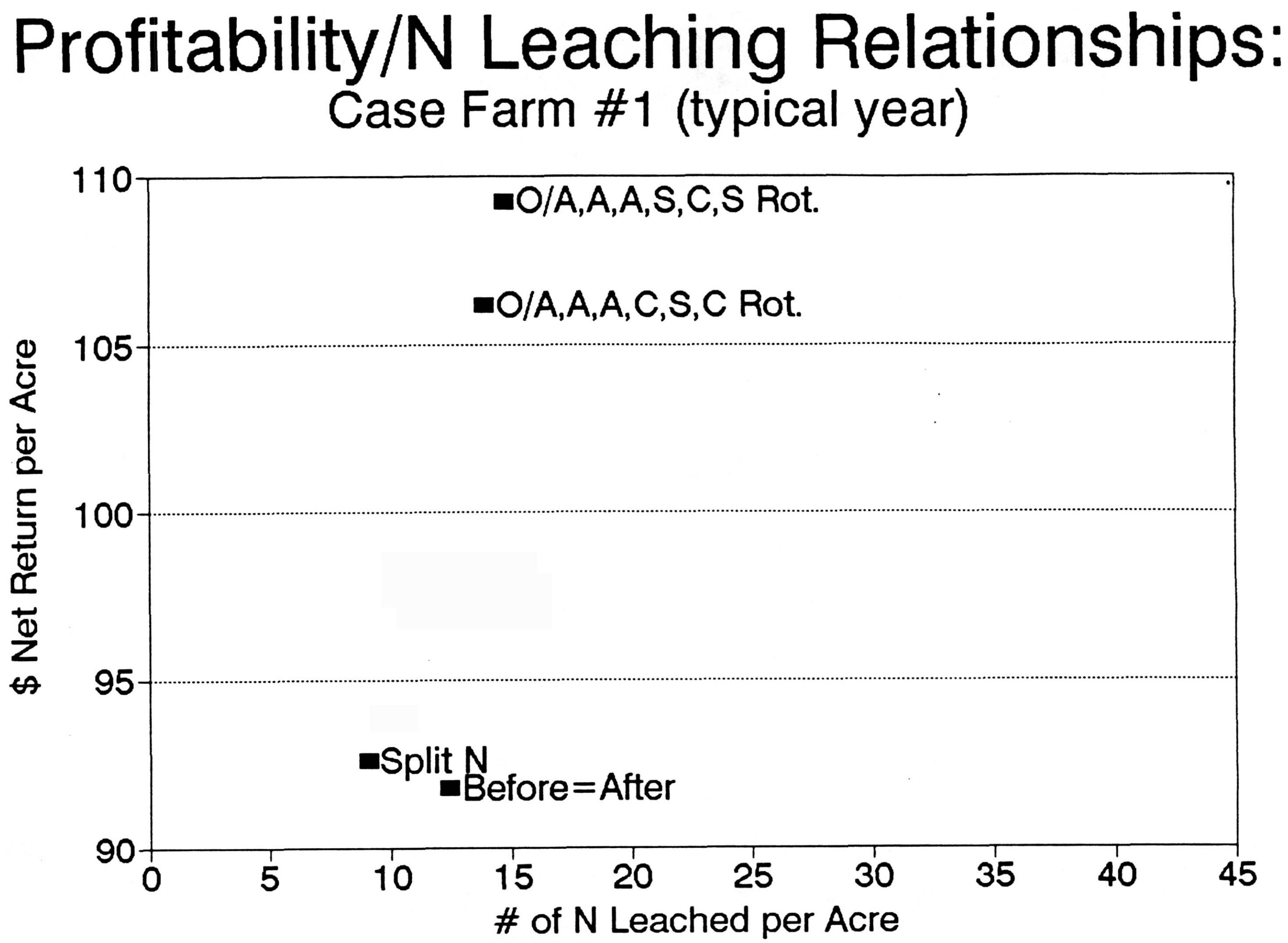
Machinery cost comparison:
Case Farm #1
Dollars per Acre
0
5
10
15
20
25
30
35
40
45
$35.37
$35.37
$35.37
$40.54
$42.72
1
4
5
9
10
Alternatives

Figure 6.



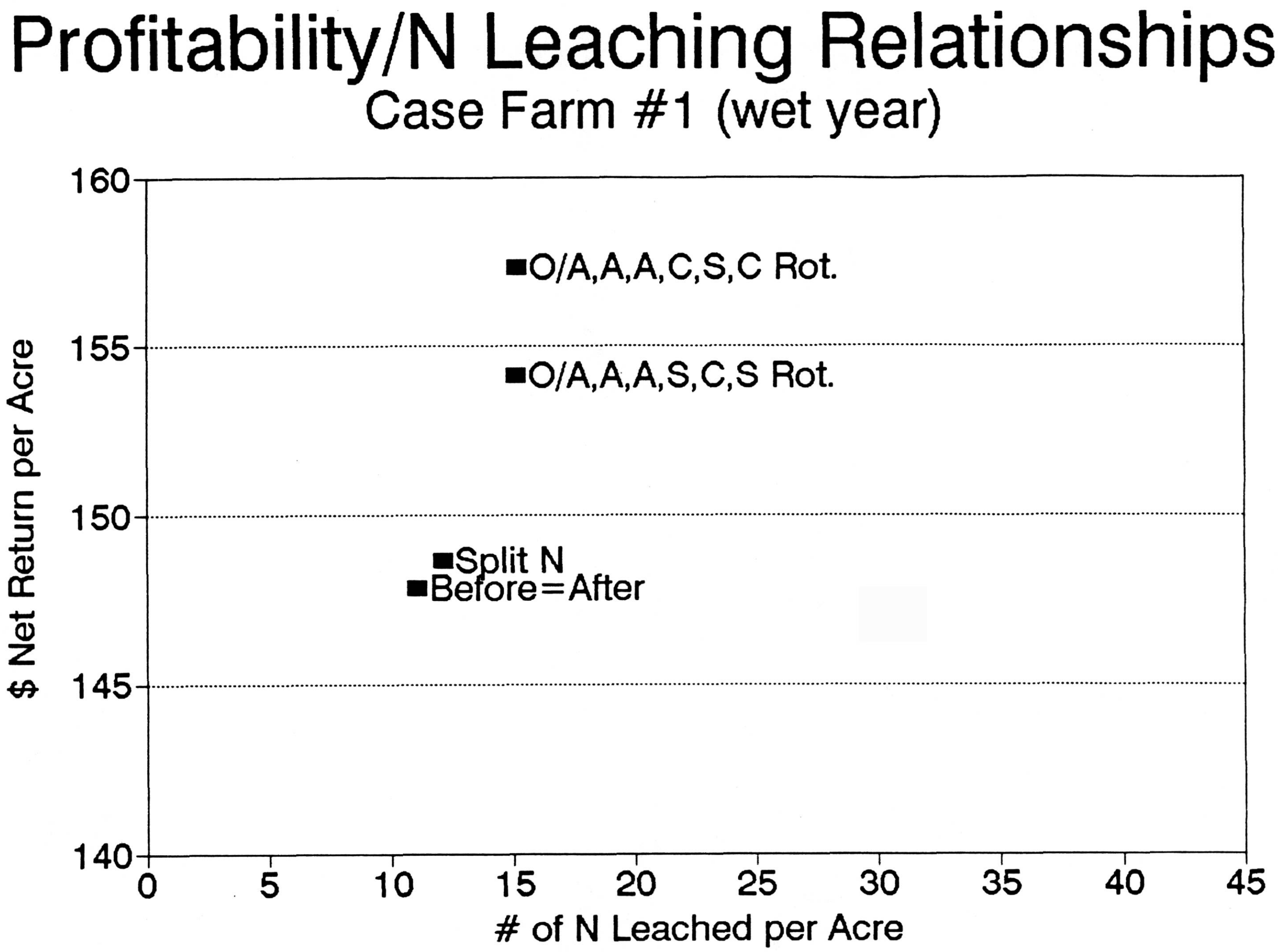
Other cost comparison:
Case Farm #1
Dollars per Acre
0
5
10
15
20
25
30
35
40
$31.11
$31.70
$33.78
$32.02
$35.81
1
4
5
9
10

Figure 7.



Profitability/N Leaching Relationships:
Case Farm #1 (typical year)
110
105
100
95
90
O/A,A,A,S,C,S Rot.
O/A,A,A,C,S,C Rot.
Split N
Before=After
$ Net Return per Acre
0
5
10
15
20
25
30
35
40
45
# of N Leached per Acre

Figure 8.



Profitability/N Leaching Relationships:
Case Farm #1 (wet year)
O/A,A,A,C,S,C Rot.
O/A,A,A,S,C,S Rot.
Split N
Before=After
$ Net Return per Acre
160
155
150
145
140
0
5
10
15
20
25
30
35
40
45
# of N Leached per Acre

Figure 9.

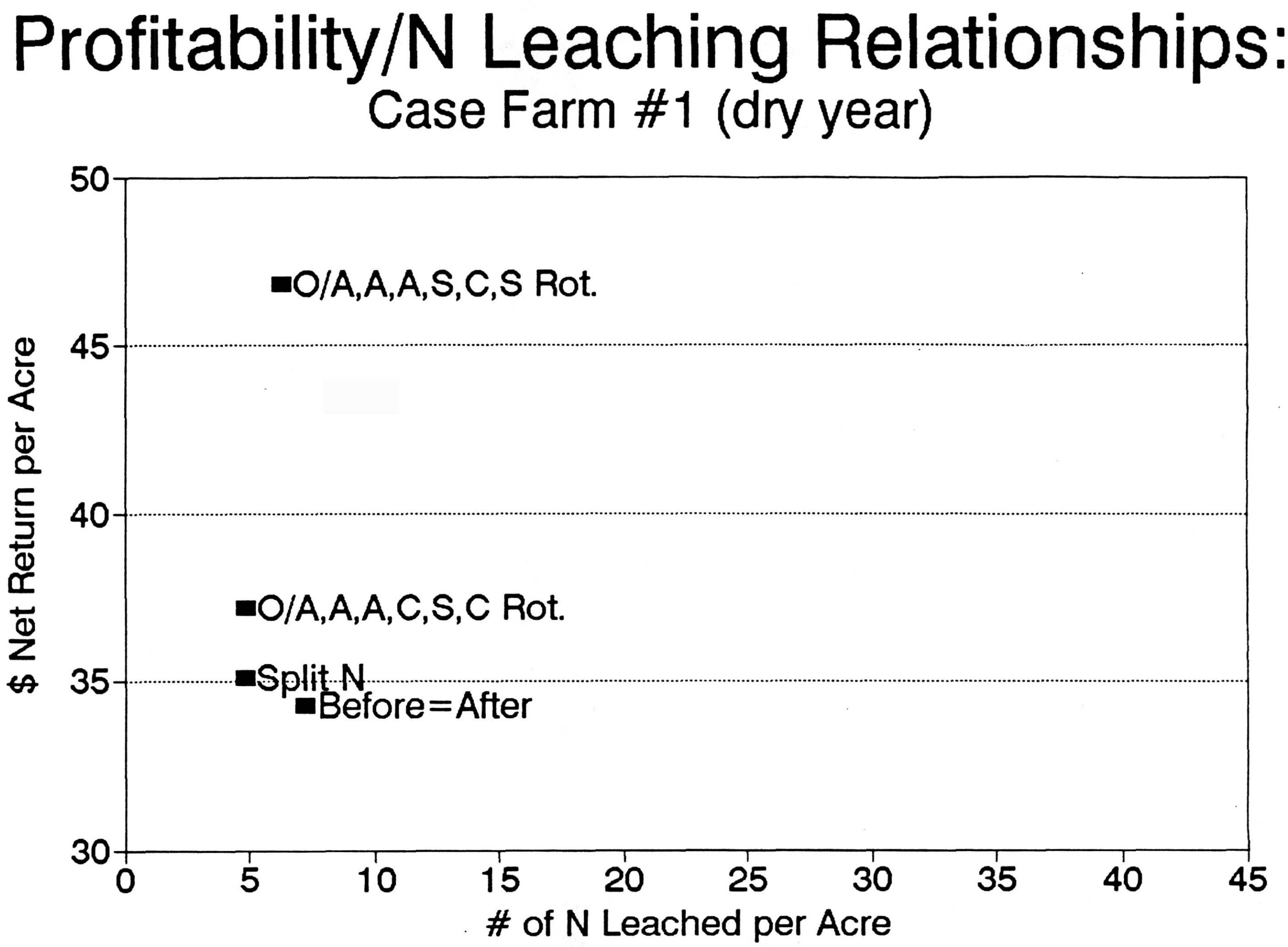
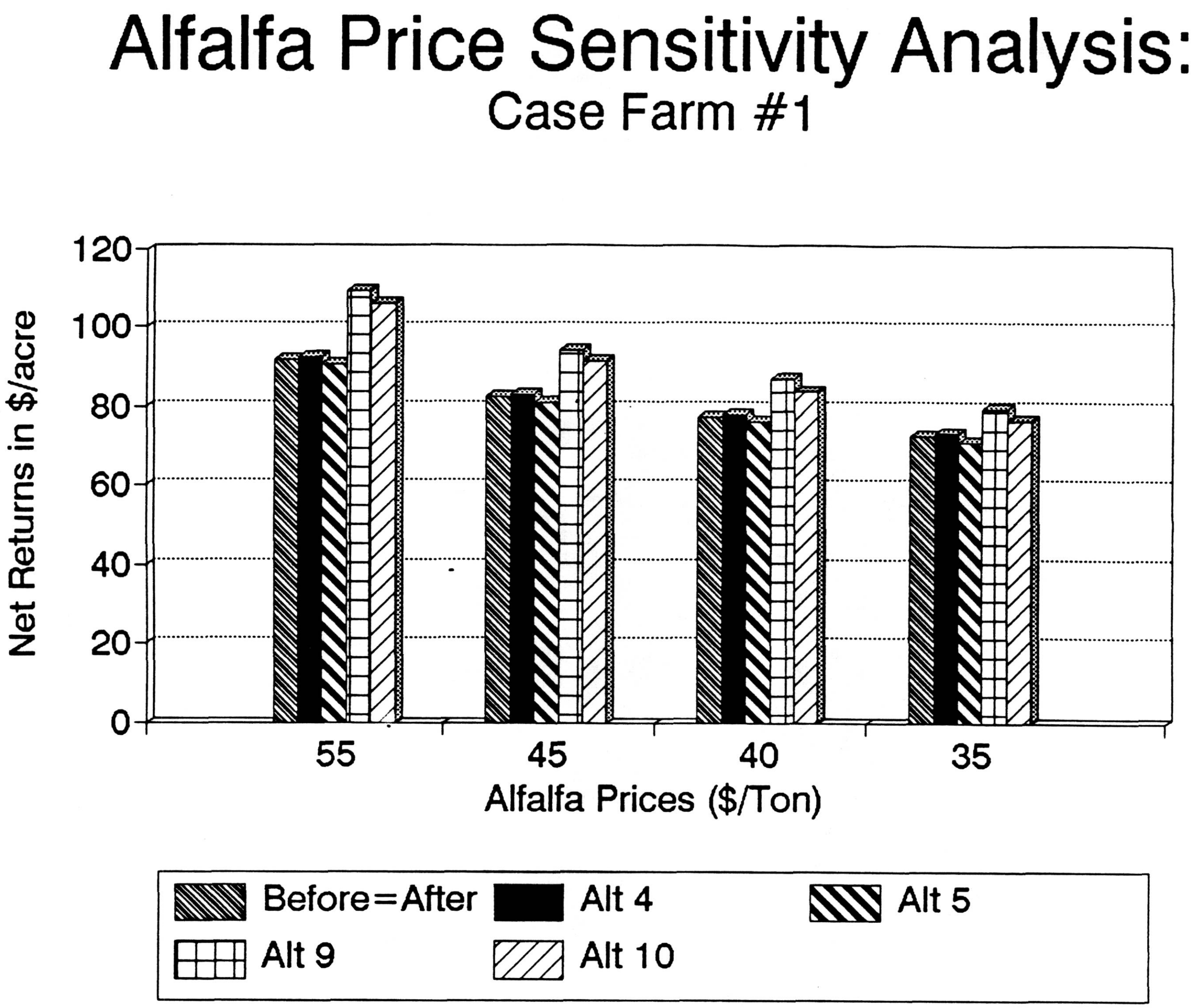
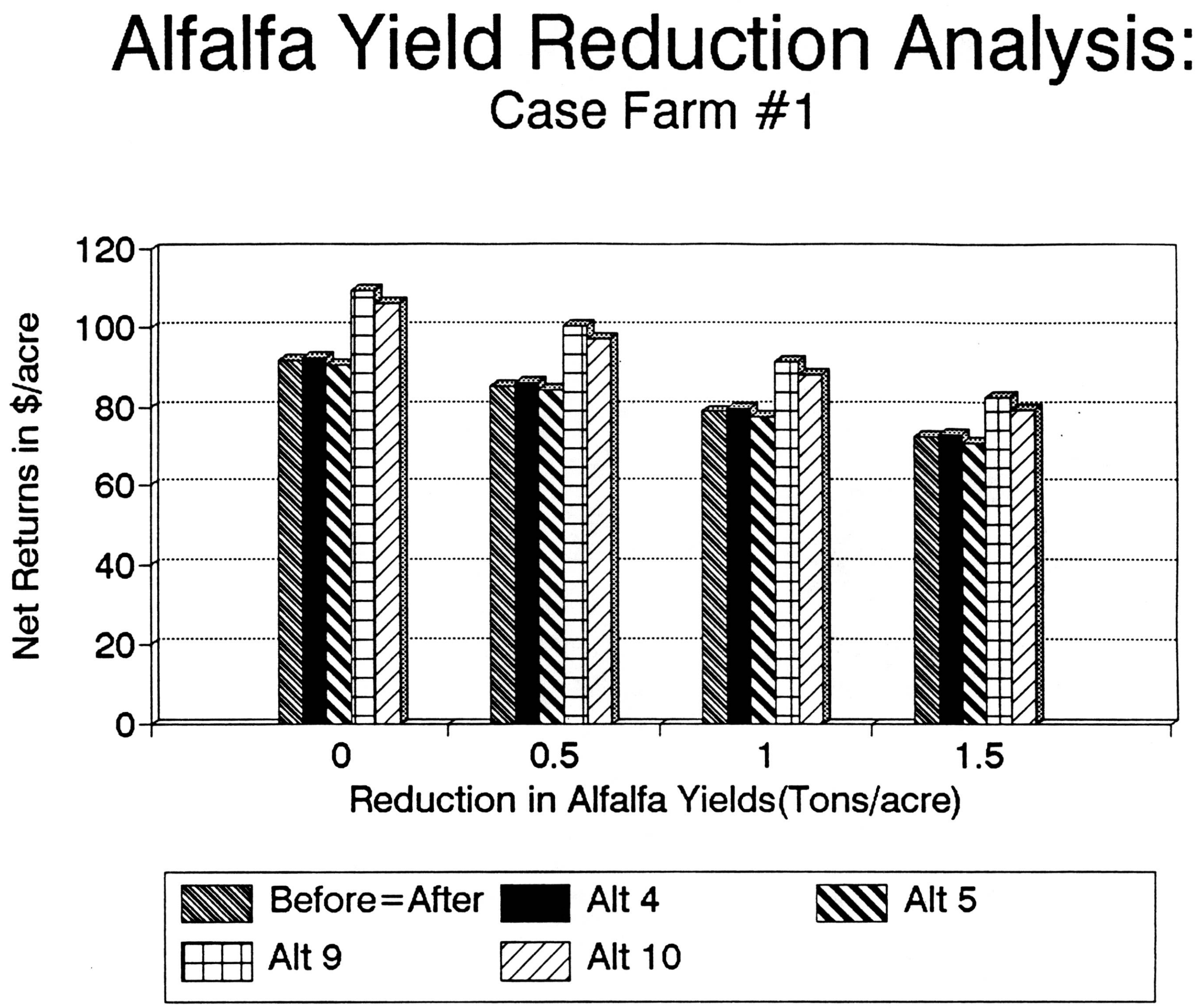

Profitability/N Leaching Relationships:
Case Farm #1 (dry year)
$ Net Return per Acre
# of N Leached per Acre
50
45
40
35
30
0
5
10
15
20
25
30
35
40
45
O/A,A,A,S,C,S Rot.
O/A,A,A,C,S,C Rot.
Split N
Before=After

Figure 10.



Alfalfa Price Sensitivity Analysis:
Case Farm #1
Net Returns in $/acre
120
100
80
60
40
20
0
55
45
40
35
Alfalfa Prices ($/Ton)
Before=After
Alt 4
Alt 5
Alt 9
Alt 10

Figure 11.


Alfalfa Yield Reduction Analysis:
Case Farm #1
Net Returns in $/acre
120
100
80
60
40
20
0
0
0.5
1
1.5
Reduction in Alfalfa Yields(Tons/acre)
Before=After
Alt 4
Alt 5
Alt 9
Alt 10