ADJUSTMENTS IN A FARM BUSINESS IN RESPONSE TO AN ENERGY CRISIS

by

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INTRODUCTION

Effects of the 1973 price increases by the Organization of Petroleum Exporting Countries (OPEC) and the boycott placed on the United States by the OPEC's Arab members awakened Americans to the reality that the U.S. depends on imported petroleum to maintain the present level of energy consumption. Awareness of this domestic energy gap has raised serious questions about the possible impacts of energy crisis conditions on U.S. agricultural production. Agricultural production in the U.S. depends on petroleum products not only for the liquid fuels used by farm machinery, but also for the manufacture of pesticides and nitrogen fertilizer.

Previous Work

Studies by Pimentel (November 1973), Heichel and Frink (February 1975), and the Steinharts (April 1974) discuss agricultural energy uses in terms of a common denominator such as kilocalories. As Castle (May 1975) has pointed out, "The reduction of all energy to a common denominator ... overlooks the differing capacity of varying energy sources to serve the interests of mankind." Batie (January 1975), in response to a Heichel paper presentation, stressed the importance of our society's "value system" of inputs and outputs and observed that "farmers are attempting to maximize income, not energy output."

The findings of Eidman, Dobbins, and Schwartz (August 1975), from energy-related studies using specified farming situations for irrigated farms in the high plains area of Oklahoma, indicated that "adoption of certain reduced tillage cropping programs will increase the level of fossil fuel inputs used" but will also "result in relatively greater increases in net returns." Their analyses also suggested the hypothesis that relatively little change in tillage practices will occur unless fuel prices increase by about 50%.

Wittmuss, Olson, and Lane (March-April 1975) found that "substantial fuel savings are possible nationally by using minimum tillage practices for row crop production." The difference in fuel usage in that study is due to fewer machinery operations in reduced tillage preharvest practices.

Vaughn, Hughes, and Smith (February 1976) and Holter (February 1976) have recently completed energy-related studies at Virginia Polytechnic Institute and State University. Vaughn, et al compared energy requirements of no-tillage and conventional-tillage corn in Virginia. They found that "no-tillage offers potential energy savings as well as better labor efficiency with increased crop yields." Energy savings were due to less machinery use under the no-tillage system. Holter's paper summarized the quantities of "major fossil fuel inputs" used in producing dairy feed. He concluded that "it appears ... that efficient handling of manure from the cow to the field and judicious use of manure nitrogen to spare chemical (manufactured) nitrogen offer the most significant potential for conservation of fossil fuel on most dairy farms."

Problem

A segment of the energy problem to which this paper is directed is, "How should a profit-oriented farmer adjust his farm business in response to circumstances which might result from the present domestic energy gap?"

Two general circumstances which might force a farmer to make adjustments in his farm business are: (1) an increase in the prices of energy-related inputs relative to output price and prices of other inputs; (2) a decrease in the availability of energy-related inputs.

While the above circumstances will have impacts on all types of livestock and crop farming, research discussed in this paper focuses on the impacts of these circumstances on the crop enterprises and feed purchases of a Grade-A dairy farm. Thus, the paper provides an example of how a farm business might be adjusted in response to an energy crisis.

Two distinguishing features of the research reported are that it evaluates responses to the energy situation from the farm manager's point of view and that it explores short-run responses and adjustments.

The need for this type of study has been expressed by Virginia Extension Farm Management Specialists desiring answers for farmers who are asking how they might adjust their farm businesses if an energy crisis occurs.

Objectives

The overall objective of the research reported is to provide information concerning alternative management adjustments to the circumstances which could occur as a result of an energy crisis. More specific objectives are to:

(1) Provide information about how a farm operator might adjust crops grown and feed purchases in response to circumstances of rising prices of energy-related inputs relative to prices of outputs and other inputs, or in response to circumstances of limited availability of energy inputs;

(2) Compare the expected income, crops grown or purchased, and energy usage resulting from alternative technologies. Specific technological alternatives evaluated for a typical dairy farm are (a) the effects of a liquid manure system compared with a solid manure system, and (b) the effects of using conventional corn tillage compared with no-tillage (no-till) corn production. Machinery operations used for conventional corn tillage are chisel plowing, once-over discing, fertilizing, planting with a conventional planter, applying herbicide, harvesting, and shredding stalks (for corn grain). Machinery operations used

for no-till corn (or corn silage) production are applying herbicides to kill cover crop and weeds, fertilizing corn, planting with a sod corn planter, applying insecticide, harvesting corn, and seeding, fertilizing, and discing in cover crop.

PROCEDURES

Resources: The research is oriented to farm situations modeled to represent typical Virginia 100-cow dairy farms. Land resources are 290 acres of open land, 46 acres productive level land suitable for continuous row crops using conventional tillage or no-till; 95 acres less fertile and more sloping, also suitable for continuous row crops with no-till production but limited to 32 acres annually with conventional tillage; 19 acres suitable for hay or pasture but not row crops; and 130 acres suitable for pasture only.

Silage storage for 1,100 tons, hay barn for 100 tons, and free-stall barn structure for 100 cows are considered typical. One farm situation is modeled to include a solid manure system and the other a liquid manure system for handling manure.

Adequate crop machinery is available to produce feed crops with various crop alternatives. Machinery requirements are slightly different as the no-till system requires a sod corn planter. Family labor (fixed) is 6,500 hours per year.

Budgets: Two dairy budgets, one with a solid manure system and the other with a liquid manure system, for a 100-cow Grade-A dairy with production of 15,000 pounds of milk per cow per year are developed. The feed inputs for cows are specified in terms of feed nutrients.

Budgets are developed for crops typical for the area. Both conventional and no-till budgets are developed for corn grain and corn silage.

In the budgets used for this study, an attempt is made to set fertilizer and pesticide use at levels which represent practices generally recommended by extension personnel at Virginia Polytechnic Institute and State University. Yields are set at levels considered to be typical for these practices. In order to explore the profitability of lower quantities of energy inputs, two budgets are developed for corn silage on land A, continuous row crop land, using no-till and conventional corn tillage, respectively, where the amounts of nitrogen and pesticides are reduced by 67% and the yields are reduced by 40%.

The no-till corn production budgets have per acre, higher yields, higher quantities of fertilizer, higher quantities of pesticides, and lower hours per acre of tillage machinery than the conventional corn tillage budgets.

Model: Four farm situations are analyzed: farms with (1) solid manure, conventional corn tillage; (2) solid manure, no-till corn production; (3) liquid manure, conventional corn tillage; (4) liquid manure, no-till corn production. Using linear programming (L.P.) models, combinations of feed crops and purchase of feed which will maximize returns to fixed resources are determined when the following are assumed: (1) 1976 prices for inputs with no restrictions on available energy inputs, (2) increases of 25%, 50%, 75%, and 100% in energy input prices, and (3) reduction in available energy inputs by 20%, 40%, 60%, and 80%. For each 25% increase in energy input prices and for each 20% reduction in energy inputs available, it is assumed that price of purchased feed will increase 25%.

RESULTS

Returns: A farm using no-till corn production has returns higher than a farm using conventional tillage, and a farm using a liquid manure system usually has higher returns than a farm using a solid manure system--the exception being when an 80% restriction of energy inputs does not make it possible to utilize all nitrogen produced by cows (Table 1).

Noteworthy results are that a 40% reduction in available energy reduces returns to management more than a 50% increase in energy prices does; and a 100% increase in energy input prices results in management returns of $300 to -$5,000, while a 60% reduction in available energy lowers management returns to -$8,590 (no-till corn, liquid manure system) and -$13,070 (conventional-till corn, solid manure system).

Crops: With 1976 energy input prices and no restrictions on energy inputs (initial situation), the no-till corn production results in higher grain production and lower corn purchases (Table 2). This is largely due to the greater acreage available to corn production and slightly higher yields with the no-till as compared to the conventional corn production system.

The most profitable cropping and feed purchase systems change only moderately in response to increased energy prices. Reductions in the availability of energy inputs, however, bring about major changes in the most profitable combinations. When the availability of fuel, pesticides, and nitrogen is reduced by 40%, grain production is reduced 45% (NT) to 58% (CT), hay production increases, and corn purchases increase. With more than 60% reductions in available energy, dairy feeding tends to become restricted largely to pasture and purchased feed.

Energy Use: Farms using the no-till corn production use more of each energy input, liquid fuels, pesticides and purchased nitrogen than farms using conventional tillage. Farms with solid manure systems purchase more nitrogen inputs than farms using the liquid manure system (Table 3).

For dairy farms with no-till corn production or farms with conventional corn production it is not profitable to decrease use of energy inputs (except

Table 1. Returns to Management on Hundred-Cow Dairy Farms, Initial Situation, Increased Prices of Energy Inputs, and Decreased Supply of Energy Inputs: No-Till and Conventional Corn Production, Solid and Liquid Manure Systems

	NT[1/]		CT[1/]	
	Solid[2/]	Liquid[2/]	Solid[2/]	Liquid[2/]
	$	$	$	$
Initial situation[3/]				
	23,393	24,818	21,453	22,878
Increased energy prices[3/]				
25%	16,958	18,629	14,513	16,184
50%	10,523	12,440	7,978	9,895
75%	4,139	6,302	1,443	3,606[4/]
100%	-2,194	305	-4,916	-2,507[4/]
Reduction in energy supply[3/]				
20%	18,388	19,813	15,304	16,729
40%	9,065	10,490	6,107	7,532
60%	-10,015	-8,590	-13,070	-11,645
80%	-38,124	-38,679[4/]	-40,037	-40,082[4/]

[1/] NT - No-till production of corn and corn silage. CT - Conventional tillage of corn and corn silage.

[2/] Solid and Liquid are types of manure systems.

[3/] Prices of energy inputs in the initial model were considered to be at the 1976 level with no restrictions on supply. Prices were increased and supply reduced for gasoline, liquid petroleum gas, diesel fuel, atrazine, paraquat, furadan, sevin, and nitrogen (also purchased feed).

[4/] In this situation excess nitrogen was furnished by manure system.

Table 2. Crops Produced and Feeds Purchased on Hundred-Cow Dairy Farms, Initial Situation, Increased Prices of Energy Inputs, and Decreased Supply of Energy Inputs: No-Till and Conventional Corn Production

	Crop grown					Feeds purchased		
Items[1/]	Grain Bu.	Corn silage Ton	Other silage Ton	Hay Ton	Pasture Acres	Soybean-meal Cwt.	Corn Bu.	Alfalfa hay Ton
				Initial situation				
NT	5,790	918	256	46	130	1,665	--	--
CT	2,155	922	252	46	130	1,571	4,002	--
				Energy price increase				
NT								
25%	Same as initial							
50%	Same as initial							
75%	6,169	785	365	46	130	1,606	--	--
100%	6,276	748	397	46	130	1,589	--	--
CT								
25%	3,588	427	505	46	130	842	5,410	--
50%	Same							
75%	Same							
100%	3,821	368	555	46	130	820	5,329	--
				Reduction in energy supply				
NT								
20%	5,319	765	333	46	130	1,409	1,476	--
40%	3,179	843	0	187	131	1,251	4,113	--
60%	2,194	546	0	137	191	822	6,563	110
80%	1,189	273	0	47	247	409	8,985	255
CT								
20%	2,432	826	301	46	130	1,430	4,274	--
40%	890	1,015	0	111	155	1,504	5,184	--
60%	2,157	528	0	94	199	796	6,671	154
80%	1,164	267	0	25	251	400	9,027	276

1/NT - No-till production of corn and corn silage. CT - Conventional tillage of corn and corn silage.

Table 3. Energy Inputs Used on Hundred-Cow Dairy Farms, Initial Situation, Increased Prices of Energy Inputs, and Decreased Supply of Energy Inputs: No-Till and Conventional Corn Production, Solid and Liquid Manure Systems[1]

	NT[2] (1000 Kilocalories used)				CT[2] (1000 Kilocalories used)			
	Liquid fuels[3]	Pesticides[3]	Purchased nitrogen[3]	Total[1]	Liquid fuels[1]	Pesticides[2]	Purchased nitrogen[3]	Total[1]
Initial situation								
	101,962	5,742	126,529	234,698	75,884	2,431	88,260	166,575
Energy price increase								
25%	101,962	5,742	126,529	234,698	111,841	2,431	46,616	160,883
50%	101,962	5,742	126,529	234,698	111,841	2,431	46,616	160,883
75%	107,581	5,702	133,806	247,090	111,841	2,431	46,616	160,883
100%	109,178	5,691	135,743	250,613	115,273	2,431	50,526	168,231
Reduction in energy supply								
20%	103,908	5,079	104,967	213,954	82,842	2,431	80,201	165,473
40%	77,058	3,996	60,178	141,232	58,260	2,570	51,171	112,002
60%	53,724	3,233	15,211	72,169	53,500	2,457	12,300	68,256
80%	27,420	2,451	0	29,870	27,267	2,063	0	29,329

1/ Nitrogen purchased is given for the liquid manure system; the use of a solid manure system increases nitrogen purchase by 3,516 pounds (29,534 1000 kilocalories).

2/ NT - No-till production of corn and corn silage. CT - Conventional tillage of corn and corn silage.

3/ Liquid fuels include gasoline, diesel fuel, liquid petroleum gas. Pesticides include atrazine, paraquat, furadan, sevin, and 2,4,D.

for nitrogen) even when prices of energy inputs are increased 100% (also 100% increase in purchased feed prices).

Low Energy Inputs Per Acre: Corn silage alternatives with 67% less nitrogen, atrazine, paraquat, and furadan inputs per acre and 40% lower yields than standard alternatives are not included in any optimum cropping system.

DISCUSSION

The results of the present research substantiate the findings of Eidman, et al ... that "adoption of certain reduced tillage cropping programs will increase the level of fossil fuel inputs used", but also "result in relatively greater increases in returns." As compared to conventional corn tillage, no-tillage corn production results in higher net returns to the farmer but also higher use of energy inputs. Farmers using no-till corn production use more energy per farm and per dollar net returns than is used by farmers using conventional corn tillage. Farms with no-till corn production have higher returns than farms with conventional corn systems because higher corn grain and corn silage yields are associated with the no-till corn system and because more acres of sloping land can be used annually for growing corn. Although the no-till corn system requires less fuel for land preparation, the no-till system uses more energy inputs in the form of nitrogen fertilizer and pesticides.

The results of the study by Eidman, et al and the results of the research reported are not inconsistent with the findings of Wittmuss, et al who report "substantial fuel savings are possible nationally by using minimum tillage practices for row crop production"; or the findings of Vaughn, et al who report "no-tillage offers potential energy savings." However, these statements need to be qualified. In the latter studies the researchers are looking at fuel savings.

Research reported in this paper assumes that fuel requirements per acre are lower but total energy requirements per acre, including nitrogen and pesticides, are higher for no-till than for conventional corn production.

The higher returns with the liquid manure system, compared to the solid manure system, emphasize conclusions made by Holter, "it appears ... that efficient handling of manure from cow to field and judicious use of nitrogen to spare chemical (manufactured) nitrogen offer the most significant potential for conservation of fossil fuels on most dairy farms."

When energy prices are increased 100%, returns to management range from $300 to -$5,000. When energy quantities are restricted 60%, returns to management range from -$8,590 to -$13,000. Farms with no-till corn production have more profitable operations but use more energy inputs per acre and per dollar returns than farms using conventional corn tillage. Both the more profitable no-till system of corn production and the severe income reductions associated with energy input rationing will cause difficult conflicts for policy makers who attempt to deal with both problems of low farm income and problems of energy conservation.

Although the research reported is oriented especially to Grade-A dairy farms in Virginia, many of the implications have applicability to other types of livestock farming and to other geographical areas.

BIBLIOGRAPHY

Batie, S. S., "Discussion of G. H. Heichel's presentation of 'Agricultural Production and Energy Resources'", Presented at College of Agriculture and Life Sciences Colloquia on January 23, 1975 at Virginia Polytechnic Institute and State University.

Berge, et al, "Considerations in Selecting Dairy Manure Handling Systems," AEN-7, Agricultural Engineering Department, 460 Henry Hall, University of Wisconsin-Madison, November 1975.

Burton, Robert Oliver, Jr., "Adjustments in a Farm Business in Response to an Energy Crisis," Thesis submitted to the Graduate Faculty of the Virginia Polytechnic Institute in candidacy for the degree of Master of Science in Agricultural Economics, July 1976, Blacksburg, Virginia 24061.

Castle, E. N., "Discussion," Paper presented in a session entitled "Recent Resource Problems of Less Developed Countries," American Journal of Agricultural Economics, May 1975.

Eidman, Vernon; Dobbins, Craig; and Schwartz, Harold, "The Impact of Changing Energy Prices on Net Returns, Production Methods and Kilocalories of Output for Representative Irrigated Farms," Paper presented at the American Agricultural Economics Association meetings at Columbus, Ohio, August 1975.

Heichel, G. H. and Frink, C. R., "Anticipating the Energy Needs of American Agriculture," Journal of Soil and Water Conservation, p. 48-53, January-February 1975.

Holter, J. B., "Revolutionary Concepts in Energy Management - Dairy Cattle," Paper presented at 30th Virginia Feed Convention and Nutrition Conference, Williamsburg, Virginia, February 20, 1976.

Murley, W. R., "Feeding Guidelines for Dairy Cows," Virginia Polytechnic Institute and State University, Extension Division Publication 630, November 1974, p. 22.

National Research Council, "Nutrient Requirements of Dairy Cattle," Nutrient Requirements of Domestic Animals, Number 3, Fourth Revised Edition, National Academy of Sciences, Washington, D.C., 1971.

Pimentel, David; et al, "Food Production and the Energy Crisis," Science, Vol. 182, p. 443-449, November 2, 1973.

Steinhart, John S. and Carol E., "Energy Use in the U.S. Food System," Science, Vol. 184, p. 307-316, April 19, 1974.

Vaughn, D. H.; Hughes, H. A.; and Smith, E. S., "Effects of No-Tillage Practices on the Energy Requirements for Corn Production in Virginia," Paper presented at the 1976 Southeast Region Meeting American Society of Agricultural Engineers, Civic Auditorium, Mobile, Alabama, February 1-4, 1976.

Wittmuss, H.; Olson, L.; and Lane, D., "Energy Requirements for Conventional Versus Minimum Tillage," Journal of Soil and Water Conservation, March-April 1975, pp. 72-75.

OTHER REFERENCES

Livestock Waste Facilities Handbook (Ames, Iowa: Iowa State University, Midwest Plan Service, 1975), p. 4.
Midwest Plan Service, 1975), p. 4.

McCart, G. D., "Manure Management: Efficient Use of An Important Source of Plant Nutrients," Grain News (Blacksburg, Va.: Virginia Polytechnic Institute and State University, Extension Division, 1976).