ECONOMIC FEASIBILITY OF FEEDLOT MANURE UTILIZATION IN COTTON PRODUCTION: AN APPLICATION TO THE TEXAS HIGH PLAINS

Jason L. Johnson and Eduardo Segarra
Department of Agricultural and Applied Economics, Texas Tech University, Lubbock, TX

Abstract

This research represents the first attempt to identify the economically feasible transportation distance for feedlot manure utilization in the Texas High Plains (THP). This analysis incorporates the residual benefits from manure and in addition provides information related to soil types, and cropping activities predominant in the THP. In many cases, the results suggest that feedlot manure utilization produces favorable yield responses for cotton (both irrigated and dryland) and appears to be a viable alternative to commercial fertilizer.

Introduction

Environmental regulations and rising fertilizer costs have made livestock waste management a critical issue to cattle feedlot operators, farmers and society at large. Solutions to waste management problems are particularly important in the Texas High Plains (THP), a semi-arid region which contains 93 feedlots with at least 5,000 head capacity, finishes out 4.5 to 5 million head of cattle, and produces approximately 5 million tons of collectible manure, annually (Bilbrey et al., 1995).

Agricultural activity in this region also includes nearly 6 million acres in crop production, many of which are both highly fertilized and intensively irrigated with groundwater from the Ogallala aquifer (Bonner et al., 1994). A decision-making process recognizing the complementary nature of fed cattle and crop production can have a positive effect on both profit and environmental goals.

The Federal Clean Water Act considers agriculture as the source of a majority of the non-point source pollution problems (Perkins, 1992). Historic under-utilization of manure has led to stockpiling at feedlots, allegedly threatening contamination of area streams, lakes, and groundwater. Cattle feedlots produce more than 60 percent of the collectible manure in Texas (Sweeten et al., 1991). A major portion of this manure has been used as cropland fertilizer, although in some cases, manure continues to be stockpiled at feedlots resulting in only negative values both economically and environmentally (Sweeten and Withers, 1990).

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 1:323-326 (1997)
National Cotton Council, Memphis TN

One of the reasons cited for low levels of manure use has been producer uncertainty regarding the merits of feedlot manure as a fertilization source. One aspect of this uncertainty among producers derives from a lack of knowledge as to the feasible transportation distance that feedlot manure can be transported and incorporated into cropping activities. Previous research by Amosson (1992) identified the feasible transportation distance for feasible manure utilization to be between 7.2 and 15.5 miles. However, residual nutrient benefits were not accounted for in this analysis. Information is needed regarding both the economic and technical feasibility related to price and quantity substitutions of fertilization sources; feasible transportation distances for feedlot manure; and rates of manure applications for selected crops.

The general objective of this study was to examine the input substitutiability between commercial fertilizer and feedlot manure for crop producers in the THP. The specific objectives were to: (1) identify the feasible transportation distance for the economic utilization of manure with respect to soil type, location, and cropping activity; and (2) identify the most profitable rate of manure application with respect to soil type, location and cropping activity.

Data and Methods

Numerous surveys have been compiled to gain insights into the adoption of technologies compatible with sustainable agriculture and to understand the barriers to adoption that exist (Sweeten, 1991; Bonner et al., 1993). A number of contemporary studies, which have addressed the impact of nitrogen fertilizer applications and nitrate-nitrogen residual on crop yields, (Segarra, 1989; Segarra et al., 1989; Schnitkey and Miranda, 1993; and Cochran and Govindasamy, 1994) have revealed that the accumulation of residual nitrate-nitrogen in sufficient quantities affects crop yields. In this study, a spatial optimization model was developed using the General Algebraic Modeling System (GAMS) (Brooke and Meerus, 1988), and EPIC (Erosion Productivity Impact Calculator), a biological soil/crop growth simulation model to estimate yield responses and irrigation water requirements resulting from utilizing feedlot manure as a soil amendment. In addition, a distinctive feature of the EPIC simulation model is the ability to explicitly account for the residual nitrogen benefits accruing from the use of fertilizer sources such as feedlot manure.

The construction of 49 separate models was required to identify the feasible transportation distances for feedlot manure utilization in the various soil type and cropping activity combinations within the cotton producing region of the THP. The objective of the spatial optimization model was to maximize net returns from crop production. These models evaluated the profitability of crop production utilizing manure from feedlots progressively more distant from the crop production area against the profitability of crop production using only commercial fertilizer. This meant that the focus of the model was primarily on the economic and technical substitutions between commercial fertilizer and feedlot manure.

The data for this research related to the predominant cropping practices in the THP region. The seven cropping alternatives included: irrigated corn (ICRN); irrigated wheat (IWHT); dryland wheat (DWHT); irrigated grain sorghum (IGRN); dryland grain sorghum (DSRG); irrigated cotton (ICTN); and dryland cotton (DCTN). Soils data were obtained from the United States Department of Agriculture (USDA) and the National Resource Conservation Service Soils 5 database. The soil series selected also represented predominant soil types across the THP region.

Seven alternative fertilization options were specified for each cropping activity assuming that feedlot manure contained 1.5 percent nitrogen and 1.22 percent phosphorous. One fertilization option involved the use of only commercial fertilizer. A second option involved using neither commercial fertilizer nor any feedlot manure. Next, five alternative rates of feedlot manure application were specified for each cropping activity and are identified in Table 1.

Commodity prices were estimated as five year averages from Agricultural Statistics for the years 1990 to 1994 (Texas Agricultural Statistics Service, (TASS), 1995). Each of the seven cropping activities were assigned 5000 acres to ensure that, after some critical distance of feedlot manure transportation, commercial fertilizer would become more profitable in the maximization of net returns.

Unique costs and returns were estimated for each cropping activity, alternative fertilization rates, and soil types predominant in the THP. The expected per-acre yield responses and variable costs of production for individual cropping activities for the commercial fertilizer application were obtained from the Texas Crop Enterprise Budgets for Districts One and Two (Texas Agricultural Extension Service, (TAES), 1995). The expected per-acre crop yields by destination and soil type as well as the irrigation requirements for the alternative manure application rates were estimated using EPIC. Variable costs associated with crop production using feedlot manure were then estimated by modifying the Crop Enterprise Budgets to recognize the differing irrigation requirements and harvesting costs related to the expected yields.

The cost of commercial fertilizer (nitrogen) was $0.12 and $0.075 per pound depending on composition. The cost of manure to area farmers was determined as a result of the latest survey of producers in the THP conducted by Bonner et al. (1994). The average costs for manure acquisition and spreading used in the spatial optimization model was $2.45 per ton. The representative transportation cost incorporated for the THP region was $0.30 per ton per mile.

Crop nutrient requirements were allowed to be fulfilled by either commercial fertilizer or from feedlot manure arriving from 200 fictitious feedlots in the THP region. These feedlots were specified to be progressively one mile farther from the crop producing destination. In other words, the first feedlot was specified at one mile from the crop production area, the second feedlot - two miles, and so on until the final feedlot was specified at 200 miles from the destination. Each of the fictitious feedlots were assigned 20 tons of manure to ensure that feedlots located within the feasible transportation distance would utilize all of their available manure. This design ensured that feedlot manure would be utilized as long as its use resulted in higher net returns than the commercial fertilizer option. Once net returns from manure use fell below commercial fertilizer, feedlot manure would be left unused at the feedlots located outside of the feasible transportation distance.

The spatial optimization model can also used to examine the sensitivity of feasible manure utilization to the relative cost of commercial nitrogen. Table 2 identifies the quantities of nitrogen applied, the price of nitrogen, and increases in variable production costs when the price of nitrogen increases by $0.03 per pound. The price of nitrogen in the crop enterprise budgets was specified at either $0.12 or $0.075 per pound depending on the composition of the nitrogen selected for application. The variable costs of production for the commercial fertilizer option were changed to reflect a price of nitrogen of either $0.15 or $0.105 per pound depending on the composition of the nitrogen selected for application. The amended estimates of variable cost were then inserted into the model to examine the effect on the feasible transportation distance for manure utilization.

Empirical Results

The economically feasible transportation distances for feedlot manure utilization in the cotton producing region of the THP are identified in 3. Feedlot manure was found to be an economically feasible source of fertilization for all cropping activities except dryland grain sorghum. Further, manure utilization was found to be economically feasible for 31 of 49 possible soil type and cropping activity combinations. The feasible transportation distance for manure utilization in the cotton production area extended to 13 miles for irrigated corn, 30 miles for irrigated grain sorghum, 12 miles for irrigated wheat, 13 miles for dryland wheat, 71 miles for irrigated cotton, and 149 miles for dryland cotton. The widespread feasibility of manure utilization across soil types and cropping activities in this area suggests that crop producers should consider feedlot manure as a viable source of fertilization to supply their crop nutrient requirements.

Each combination of cropping enterprise, destination, and soil type ecosystem was then re-modelled to provide some insight into the sensitivity of the feasible transportation

distance for manure utilization (Table 4). The 49 models used to identify the economically feasible transportation distance were modified to reflect a $0.03 per pound increase in the price of commercial fertilizer (nitrogen). It was assumed, for these scenarios, that: manure acquisition and spreading cost remained at $2.45 per ton, manure transportation cost remained at $0.30 per ton per mile, but that the cost of commercial fertilizer (nitrogen) was increased to $0.15 and $0.105 per pound depending on composition.
Manure utilization, for this situation, is economically feasible for 34 of 49 possible soil type and cropping activity combinations. Once again, manure utilization was found to be appropriate in all cropping activities except dryland grain sorghum. The increased price of commercial fertilizer expands the feasible transportation distance for manure utilization in the cotton production area to 15 miles for irrigated corn, 32 miles for irrigated grain sorghum, 13 miles for irrigated wheat, 14 miles for dryland wheat, 73 miles for irrigated cotton, and 153 miles for dryland cotton.

Summary

This study attempted to bring together both theoretical and empirical methods of economic analysis to investigate the utilization of feedlot manure in crop production practices of the THP. This research represents the first attempt to identify the economically feasible transportation distance for feedlot manure utilization which incorporates the residual benefits from manure and in addition provides information related to soil types, and cropping activities predominant in the THP. The resulting feasible transportation distances were found to be substantially greater than those previously identified. This further supports the findings of Segarra (1989), Segarra et al. (1989), and Cochran and Govindasamy (1994) that residual nitrogen benefits must be accounted for in evaluations of manure utilization.

Procedures were outlined for the construction of a spatial optimization model to evaluate the input substitutability between commercial fertilizer and feedlot manure in the predominant cropping practices in the THP. The results suggest that the utilization of feedlot manure in crop production can benefit THP feedlots by serving as an environmentally preferred manner of waste disposal to the widespread practice of stockpiling. Feedlot manure also appears to benefit crop producers in the THP by providing a more profitable source of plant nutrients (in many cases).

Since each cropping activity and soil type combination was modelled separately, comparisons between the profitability of alternative crops cannot be identified. However, the results suggest that feedlot manure utilization produces favorable yield responses for cotton (both irrigated and dryland) and appears to be a viable alternative to commercial fertilizer. Moreover, the economically feasible distance for manure utilization in cotton production across soil types is frequently greater than the economically feasible distance for other predominant cropping alternatives in the THP.

Acknowledgements

The authors would like to acknowledge the contribution of T.R. Owens, Sukant Misra, and Marty Middleton to the work reported in this manuscript. Texas Tech University, College of Agricultural Sciences Publication Number T-1-443.

References

Amosson, S.J. 1992. Inorganic Fertilizer Versus Manure: An Economic Comparison. In: Feedyard Manure: A Farmland Fertilizer. Texas Agriculture Extension Service, Texas A&M University, Amarillo, TX.

Bilbrey, Donna, Greg Boggs, and Dave Krupnick. 1995. Cattle Feeding Capital of the World, 1995 Fed Cattle Survey. Southwestern Public Service Co., Amarillo, TX.

Bonner, Barbara, S.H. Amosson and W.L. Harman. 1994. Manure Utilization Preferences by Texas High Plains Farmers. Texas Agricultural Experiment Station, Texas A&M University System. PR-5149, (October).

Bonner, Barbara, S.H. Amosson and W.L. Harman. 1993. Logit Analysis of Producer Preferences for Utilizing Manure. Texas Agricultural Experiment Station.

Brooke, A., D. Kendrick, and A. Meerus. 1988. GAMS, A User's Guide. The Scientific Press, San Francisco, CA.

Cochran, Mark J. and Ramu Govindasamy. 1994. Market Solutions to Excess Litter Applications of Poultry Litter. Staff Paper 0794, Department of Agricultural Economics and Rural Sociology, University of Arkansas, Fayetteville, AR.

Perkins, Doug. 1992. A Chat On The Clean Water Act. Beef Feeder. 36:8-10.

Schnitkey, Gary D. and Mario J. Miranda. 1993. The Impact of Pollution Controls on Livestock-Crop Producers. Journal of Agricultural and Resource Economics. 18(1):25-36.

Segarra, Eduardo. 1989. Optimizing Nitrogen Use in Cotton Production. In: Proceedings of the 21st Annual Summer ComputerSimulation Conference. pp. 722-726.

Segarra, Eduardo, Don E. Ethridge, Curtis R. Deussen, and Arthur B. Onken. 1989. Nitrogen Carry-Over Impacts in Irrigated Cotton Production, Southern High Plains of Texas. Western Journal of Agricultural Economics. 14(2):300-309.

Sweeten, John M., Mark McFarland, B.L. Harris, Gary Westmoreland, Charles Baird, and Leah Manning. 1991. Animal Waste Application. Leaflet 5044, Texas State Soil and Water Conservation Board, Temple, TX and Texas Agricultural Extension Service, College Station, TX.

Sweeten, John M. 1991. Summary of TCFA/TAEX Survey Results -- Use of Feedlot Manure for Fertilizer, 1991. unpublished data,Texas Agriculture Extension Service, College Station, TX.

Sweeten, John M. and Richard E. Withers, Jr. 1990. Feedlot Manure Drops in Texas. Beef, 27 (2):54-55.

Texas Agricultural Extension Service. 1995. Texas Crop Enterprise Budgets. Texas A&M University, College Station, TX.

Texas Agricultural Statistics Service. 1990-1994. Texas Crop Statistics. Texas A&M University, College Station, TX.

Table 1. Manure Application Rates for Various Cropping Activities.[a]

	MANURE APPLICATION LEVELS				
	RONE	RTWO	RTHR	RFOR	RFIV
CROP	---------------------- TONS PER ACRE ------------------				
CORN					
Irrigated	8.23	9.61	10.98	12.35	13.72
WHEAT					
Irrigated	5.49	6.86	8.23	9.61	10.98
Dryland	1.37	2.74	4.12	5.49	6.86
GRAIN SORGHUM					
Irrigated	5.49	6.86	8.23	9.61	10.98
Dryland	1.37	2.06	2.74	3.43	4.12
COTTON					
Irrigated	2.06	2.74	3.43	4.12	4.80
Dryland	0.67	1.37	2.06	2.74	3.43

[a] In addition to the five non-zero rates of manure application, a sixth application rate (RZER) involving no fertilizer application was also incorporated. A seventh manure application rate (RCOM) was also considered and involved no manure applications and represented a commercial fertilizer option. In each of these cases, the manure applied to cropping enterprises is zero across all enterprises.

Table 2. Quantities of Commercial Nitrogen Applied, Nitrogen Prices and Increased Production Costs Resulting from $0.03 per Pound Increases in Commercial Nitrogen Prices.

COTTON PRODUCING REGION OF THE THP			
CROP	POUNDS OF COMMERCIAL NITROGEN	REVISED PRICE OF NITROGEN ($/LB.)	INCREASED PER ACRE PRODUCTION COSTS
CORN			
Irrigated	275	$0.15	$8.25
GRAIN SORGHUM			
Irrigated	120	$0.15	$3.60
Dryland	30	$0.105	$0.90
WHEAT			
Irrigated	100	$0.15	$3.00
Dryland	30	$0.105	$0.90
COTTON			
Irrigated	50	$0.15	$1.50
Dryland	20	$0.105	$0.60
Sandy Soils			
Irrigated	40	$0.105	$1.20
Dryland	30	$0.105	$0.90

Table 3. Feasible Transportation Distances for Manure Utilization in the Texas High Plains when Commercial Nitrogen is Priced at $0.12 and
$0.075 per pound for Various Compositions.[a]

	ICRN	ISRG	DSRG	IWHT
SOIL TYPE	----- FEASIBLE DISTANCE (IN MILES) -----			
Amarillo	0	20[RTHR]	0	0
Acuff	4[RFIV]	25[RTWO]	0	0
Portales	0	24[RTHR]	0	1[RFIV]
Miles	- -	9[RTHR]	0	0
Olton	0	24[RTHR]	0	0
Steiner[b]	13[RFIV]	30[RFIV]	0	12[RFIV]

	DWHT	ICTN[c]	DCTN[c]
SOIL TYPE	----- FEASIBLE DISTANCE (IN MILES) -----		
Amarillo	13[RTHR]	16[RFIV] 28[RFIV]	18[RTHR] 43[RTHR]
Acuff	3[RTHR]	20[RFOR] 33[RFOR]	0 34[RTWO]
Portales	3[RTHR]	- - 26[RFIV]	- - 19[RTHR]
Miles	8[RTHR]	10[RFOR] - -	0 - -
Olton	0	45[RTHR] 71[RONE]	74[RONE] 149[RONE]
Steiner[b]	0	29[RTWO] 49[RTWO]	0 9[RONE]

[a] Superscripts (RONE, RTWO, RTHR, RFOR, and RFIV) refer to the manure application rate which is specifically identified in Table 1.

[b] The Steiner soil series is representative of the productive capabilities of both Sherm and Pullman soil types.

[c] For ICTN AND DCTN cropping activities, the top mileage corresponds to the feasible distances for Deaf Smith, Randall, Armstrong, Donley, Parmer, Castro, and Swisher counties. The bottom mileage corresponds to feasible distances for Bailey, Lamb, Hale, Floyd, Cochran, Hockley, and Lubbock counties.

Table 4. Feasible Transportation Distances for Manure Utilization in the Texas High Plains when Commercial Nitrogen is Priced at $0.15 and $0.105 per pound for Various Compositions.[a]

SOIL TYPE	ICRN	ISRG	DSRG	IWHT
	----- FEASIBLE DISTANCE (IN MILES) -----			
Amarillo	1[RFIV]	21[RTHR]	0	0
Acuff	6[RFIV]	26[RONE]	0	0
Portales	1[RFIV]	26[RTHR]	0	2[RFIV]
Miles	- -	11[RTWO]	0	0
Olton	1[RFIV]	25[RTHR]	0	0
Steiner[b]	15[RFIV]	32[RFOR]	0	13[RFIV]

SOIL TYPE	DWHT	ICTN[c]	DCTN[c]
	----- FEASIBLE DISTANCE (IN MILES) -----		
Amarillo	14[RTHR]	17[RFIV] 30[RFIV]	19[RTHR] 44[RTHR]
Acuff	3[RTHR]	21[RFOR] 34[RFOR]	0 35[RTWO]
Portales	3[RTHR]	- - 27[RFIV]	- - 21[RTHR]
Miles	9[RTHR]	11[RFOR] - -	0 - -
Olton	0	47[RTHR] 73[RTHR]	77[RONE] 153[RONE]
Steiner[b]	0	31[RTWO] 51[RTWO]	0 14[RONE]

[a] Superscripts (RONE, RTWO, RTHR, RFOR, and RFIV) refer to the manure application rate which was is specifically identified in Table 1.

[b] The Steiner soil series is representative of the productive capabilities of both Sherm and Pullman soil types.

[c] For ICTN AND DCTN cropping activities, the top mileage corresponds to the feasible distances for Deaf Smith, Randall, Armstrong, Donley, Parmer, Castro, and Swisher counties. The bottom mileage corresponds to feasible distances for Bailey, Lamb, Hale, Floyd, Cochran, Hockley, and Lubbock counties.