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Investment Analysis of Commercial Variable Rate and Conventional Fertilizer Spreading Systems

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Introduction

The rapidly changing production agriculture environment necessitates the investigation of new technologies such as variable-rate fertilizer application. There is significant demand for information pertaining to the ownership and operation costs of this technology. Suppliers, vendors, and custom applicators need data to make sound investment decisions. Producers have expressed a desire to investigate the use of this technology. Many producers, especially the larger producers, might be interested in this study as they consider investment opportunities.

The goal of variable-rate fertilizer application is to place soil nutrients in areas where nutrients will be most beneficial. Agronomic research, with respect to variable-rate nitrogen fertilization, soil fertility, soil conservation, and environmental stewardship is currently under way at numerous locations. These research efforts are conducted in an attempt to determine, from a producer's standpoint, the economic, physical, and chemical feasibility of this technology. Research with a specific focus on investment is needed as well *(1-9)*.

The purpose of this study was to develop a net present value investment analysis for several popular fertilizer application systems. These systems include multibin, pneumatic application systems; conventional, single-bin, pneumatic systems; and conventional spin-spreader systems. A traditional net present value investment analysis was conducted in an attempt to aid decision-makers and potential users or purchasers of variable-rate application technology. This study had three objectives:

1. Collect data on the purchase prices of a multibin variable-rate fertilizer applicator and conventional fertilizer application systems.

2. Compare and contrast the features of multibin variable-rate fertilizer application systems to conventional fertilizer application systems.

3. Analyze the data using traditional investment analysis.

Methods and Procedures

The data for this research were compiled by personal and telephone interviews of commercial vendors and custom applicators who own and operate conventional spin-spreader applicators; single-bin, pneumatic applicators; and multibin, pneumatic applicators. Information was solicited to estimate repair and maintenance costs, purchase price, and useful life of the equipment. Another focus of the interviews was to determine the amount of operator labor required, the skill level required, and its associated costs. Other relevant questions addressed cost and quantity of additional tender trailers, trucks, and labor required. The authors also obtained estimates of fuel consumption, downtime, and perceptions of applicators and producers regarding acceptance of the technology. Questions about current acreage charges for various service packages were also asked.

Personal and telephone interviews were conducted with vendors and custom applicators who did not own multibin, pneumatic application equipment. These individuals were asked about the systems they currently operated. They were asked about information they needed before considering investment in variable-rate technology. Appropriate application charges for variable-rate service was one of the predominant concerns. Costs and charges associated with field mapping, gridding, and soil sampling were significant considerations, along with additional equipment and labor to achieve these tasks. Field mapping, gridding and soil sampling, the primary procedures leading to development of a prescription map, are vital components of variable-rate application and were major concerns. Incorporating yield data from harvester yield monitors into the prescription map was a concern. Some vendors and applicators had concerns regarding the reliability and acceptance of these additional requirements by producers. These components are not the subject of this study, however, but do represent significant concerns.

Equipment manufacturers and suppliers contacted were instrumental in the development of data for this research. They were beneficial in locating local vendors, field representatives and sales personnel who were eager to aid in research development *(10)*.

Assumptions

Assumptions regarding certain parameters are an essential part of any analysis. Assumptions for this study include an estimated useful life of 10 years for application equipment and 10 years for tender equipment. Annual hours of use result from days available for fieldwork and an assumed percentage of the days available that an operator would and could use for operation *(11)*. The number of days of operation depends on demand by customers and available supply of services. There is a modest period within which fertilizer application can be accomplished. This period varies by vendor and is determined partly by quantity of application, type of tender equipment available, type of crop production, and most importantly weather. Market territory and market share for any particular vendor also determines the actual acreage covered. Annual periods were divided into quarters. The first period is primarily winter, when little fieldwork is done. Period 2 comes in spring, when fieldwork, planting, and quite a bit of fertilizer application are performed. The season slows again during the summer period, as crops are growing. During the fall, period 4, fertilizer applications resume when harvest is complete and weather is dry. Table 1 indicates the total days suitable for fieldwork by assumed period in Mississippi. The assumed days of operation by period and the assumed percentage of days suitable by period are also given.

Table 1. Total days suitable for fieldwork by period in Mississippi.					
	Period 1 Jan. 1 - Feb. 25	**Period 2 Feb. 26 - June 17**	**Period 3 June 18 - Sept. 9**	**Period 4 Sept. 10 - Dec. 30**	**Total days suitable**
Days suitable by period [1]	15	56.3	59.4	64.5	195.2
Assumed days of operation by period	3.00	22.52	11.88	22.58	59.98
Assumed percentage of days suitable by period	20%	40%	20%	35%	

[1]Source: MAFES Bulletin 1026, May 1995, Spurlock, et al.

Repair and maintenance of equipment was initially expressed as a percent of investment cost over a 10-year useful life. It was assumed that the total for repairs and maintenance would be 50% of the new price over the life of the machinery. The assumption was further refined, presuming the majority of repairs would occur toward the end of the useful life of the equipment. This methodology led to a segmented repairs and maintenance schedule with 20% of the total repairs equally assigned in years one through three, 30% of the total in years four through six and the remaining 50% of total during years seven through 10.

A discount rate of 10% was used in the initial investment analysis. The estimated net revenue stream for each application system described was discounted quarterly for 10 years of operation. A zero salvage value for equipment was assumed.

There were also assumptions regarding labor utilization. Based on days suitable for operation and the assumed days of operation, labor was not fully employed. It is assumed that labor will be utilized in other elements of the overall organization when not engaged in fertilizer application. Therefore, charges for labor were only made for time spent in the fertilizer spreading operation.

Application Charges

The majority of vendors and custom applicators interviewed in the Delta region primarily operated the single-bin pneumatic fertilizer applicators with an increasing number operating multibin, pneumatic applicators. Both conventional spin-spreader and single-bin pneumatic applicators are found in the Coastal Plain, Brown Loam, and Black Belt regions of the state.

The rate structure among vendors and custom applicators in the Delta is remarkably competitive and is partially based on market territory, total amount of acreage covered, and contention for market share. The application rate structures in the other regions of the state are also competitive, but they are somewhat more standardized due to type of application equipment and fertilizer utilization. Vendors in these regions continue to operate the spin-spreader applicators due to cost, production field size, livestock enterprises, and hay or forage production.

The charges for fertilizer application in the Delta are classified into three categories; broadcast application single-bin, pneumatic applicator; blend on-the-go application of two elements; and variable-rate application. The difference in broadcast application rates is not significant in the Delta. Equipment and labor costs are proportional to market territory and market share, and the cooperation among competitors is maintained at high levels to protect customer base and market share. The broadcast application rates in other regions are also uniform.

The blend on-the-go and variable-rate application charges are moderately similar among vendors and are concentrated in the Delta. There is some competition for market share in the variable-rate and blend on-the-go markets, but the application charges for these services remain quite similar among vendors. There are some cost differences regarding field mapping, gridding, and soil sampling charges among vendors offering these application services. These differences can be attributed to a number of factors, some of which include cost of additional equipment and personnel, producer demand for services, and total acreage base. Both application methods afford the vendor the option of delivering fertilizer material directly from the terminals – located along the Mississippi River – to the producer's field, eliminating some handling of the material at the vendors' headquarters.

It should be noted that distance from the producer's field to fertilizer terminals or stocks largely influences application and material delivery for the blend on-the-go or variable-rate systems. Vendors and custom applicators operating on the eastern side of the Delta or in other areas distant to river terminals must maintain sufficient supply at their respective headquarters. This requires additional handling as well as sufficient storage facilities and equipment. Increased use of tender equipment is an alternative but may cause logistical or downtime problems during peak periods of operation. This supply problem may require engaging an independent contractor to transport fertilizer to headquarters terminals or the purchase of adequate transportation equipment to handle fertilizer demand at peak periods. Table 2 presents estimated average application rates for the four application systems outlined previously.

The prices reported in Table 2 represent actual prices charged by various vendor applicators and custom applicators. The average price was computed using a **simple, unweighted average for analysis purposes only** and should not be taken as an industry or statewide average application charge. These average values are used to estimate incomes for each of the four systems evaluated.

Table 2. Observations and average fertilizer application charges per acre, Mississippi, 1998.[1]

Observation	BA spin spreader (single)	BA spin spreader (blended)	BA spin spreader	BA SB pneumatic (single)	BA SB pneumatic (blended)	Blend on-the-go multibin applicator	Variable-rate multibin applicator
	$	*$*	*$*	*$*	*$*	*$*	*$*
1				4.00	4.00	6.00	8.00
2			2.50			6.50	8.50
3	2.50	2.50	2.50				
4	3.50	2.50	3.50				
5			2.50	4.00	4.00		
6	3.50	5.00	3.50				
7			5.00	4.00	4.00	6.00	8.00
8				4.00	4.00	6.00	7.50
9				4.50	4.50	6.50	7.00
Average	3.17	3.33	3.25	4.10	4.10	6.20	7.80

[1]BA = broadcast application; SB = single-bin pneumatic applicator; single = single element applied; and blended = blended fertilizer applied.

Summary Description of Application Equipment

There are four commonly utilized fertilizer application technologies. The first is a tractor-drawn, single-compartment, 5-ton applicator, typically used by livestock or small-scale agricultural operations. Second is the conventional, single-compartment, spin-spreader bed mounted on a standard 2-ton or larger truck. Third is the single-bin, pneumatic applicator mounted on a heavy-duty truck chassis or a high-flotation, truck-type frame with either three- or four-wheel drive. Fourth and latest is the multibin, pneumatic applicator, similar in construction to the single-bin, pneumatic applicator mentioned previously but capable of applying several different fertilizer materials simultaneously.

The vendors and custom applicators interviewed for this study operate primarily two-bin fertilizer applicators, although one vendor/applicator used a four-bin applicator with two optional granular bins for microelements or herbicides. Of the applicator manufacturers interviewed for this study, all utilized 304-grade stainless steel, except one who used 409 grade. Some applicator manufacturers offered mild steel construction as an option, but this alternative is seldom used, as most fertilizer material is corrosive.

Four application systems are described in this bulletin. The tender equipment needed to support and deliver fertilizer material directly to the applicator in the field is also described for each system.

Both the truck-mounted spin-spreader applicator and the single-bin, pneumatic applicator may be equipped with a Global Positioning System (GPS) receiver capable of interfacing with the controller to facilitate variable-rate application. Variable-rate application is based on a prescription map developed, in part, from yield monitor data, agricultural consultant recommendations, and soil sample analysis.

The most common application of a GPS receiver is in the multibin, pneumatic, variable-rate application system. This system is capable of applying two or more materials simultaneously and relies on the GPS receiver to provide location data. These data are vital to accurate system controller response to the prescription map. The single-compartment spin-spreader applicator is typically not equipped with variable-rate technology due to its inability to apply more than one material. However, this unit is capable of applying variable-rate agricultural limestone when used with the appropriate technology and accessories.

Some custom applicators and vendor applicators applying variable-rate agricultural limestone were located during the field surveys conducted for this research. However, neither the variable-rate application of agricultural limestone nor the tractor-drawn fertilizer applicator is included, as the focus of this study is the economics and investment requirements of commercial, large-scale fertilizer application methods.

The conventional applicator typically consists of a stainless steel, sloped side bed with a stainless steel bed chain used to move the material to spinners mounted at the rear of the bed. A material door enables fertilizer to exit, and a controller for the system capacitates operation from within the cab. Most modern applicators now include a radar system as well. The radar system monitors ground speed and interfaces with the controller to ensure the application rate is matched to the ground speed based on fertilizer requirements for the respective field.

The spreading mechanism is powered by a PTO-powered hydraulic pump. The controller is interfaced with a flow-metering valve between the hydraulic pump and the hydraulic motor that operates the bed chain. The spinners operate at a constant rate of speed and have vertical vanes or fins mounted on the top surface to propel the material into a spread pattern. The controller adjusts the speed of the bed chain by varying the speed of the hydraulic motor in order to maintain required application rate. The rate of flow is adjusted to ground speed by the radar system. The adjustable material door at the rear of the bed can be cross-referenced with manufacturer's specifications to achieve required fertilizer application based on fertilizer type and density.

The truck chassis used for this type of applicator varies depending on operator and owner preference. One local vendor sells new applicator beds and mounts on high-quality used or reconditioned truck chassis. Several manufacturers build applicator beds and purchase new truck chassis for installation, based on customer order or industry demand. These truck chassis vary in accessories, transmissions, drive trains and engine horsepower and displacement. However, the most common seem to be diesel engines with a minimum of 250 horsepower.

Typical accessories include, but are not limited to, flotation tires of various sizes and configurations, a heavy-duty automatic transmission, and heavy-duty front and rear axles. The flotation tires are an after-market product that allow operation in muddy conditions. The heavy-duty axles are added to compensate for the oversized flotation tires. The heavy-duty transmission is installed to enable efficient variable speed operation and simplify road travel. One of the most common deployments of this type of applicator is broadcast application of a blended fertilizer material from local fertilizer vendors. This applicator may also be utilized to spread a single fertilizer material, such as ammonium nitrate or agricultural limestone, which is typically a fall cultural practice.

For purposes of this study, both types of trucks were included to represent typical conventions. However, the purchase of a new truck chassis and new spin-spreader body was assumed for analysis. Table 3 provides estimated industry average list prices for the spin-spreader unit, various truck chassis, and field-ready units with both types of truck chassis. Hence, $68,115 is the total investment assumed required for System 1. Table 4 gives estimated operation costs and returns for System 1. Table 4 is based on assumed days and hours of operation discussed previously. Costs and returns are included for the first year only based on assumed days and hours of operation. It is assumed for decision-making purposes that charges for repairs and maintenance are the only changes that impact cost differences in the remaining 9 years of assumed useful life. These changes are reflected in estimated net revenue calculations presented in the results.

Table 3. Individual observations and average list prices for conventional spin-spreader applicators.

Observation	Spin-spreader bed	Flotation option (both axles)	Used truck chassis	Used truck chassis w/ spreader	New truck chassis	New truck chassis w/ spreader
	$	$	$	$	$	$
1	17,900	8,800	23,000	44,730	48,000	67,230
2	18,500	11,000	23,000	47,250	48,000	69,750
3	17,850	9,000	23,000	44,865	48,000	67,365
Average [1]	18,083	9,600	23,000	45,615	48,000	68,115

[1]New and used truck prices reflect cost of heavy-duty axles and heavy-duty automatic transmissions. Estimated average list prices include radar system and in-cab controller. Estimated list prices do not include any dealer discounts or promotions.

Table 4. Operation costs and returns for System 1, Year 1.

Item (unit)	Quantity units/hour	Price per unit	Amount per hour	Amount per day	Amount Period 1	Amount Period 2	Amount Period 3	Amount Period 4	Amount Total
		$	$	$	$	$	$	$	$
Income:									
Spreading (acre)	35.00	3.25	113.75	1137.50	3,413	25,617	13,514	25,679	68,222
Expenses:									
Fuel (gal)	8.50	1.20	10.20	122.40	367	2,756	1,454	2,763	7,341
Labor (hr)	1.00	10.00	10.00	120.00	360	2,702	1,426	2,709	7,197
Repair & maint. (hr)	1.00	3.79	3.79	37.86	114	853	450	855	2,271
Total cost			**23.99**	**280.26**	**841**	**6,311**	**3,329**	**6,327**	**16,808**
Net revenue					**2,572**	**19,305**	**10,184**	**19,352**	**51,413**

System 2. Conventional Spin-Spreader Applicator with Tender

The applicator for System 2 is essentially identical to the applicator described under System 1. The difference between the two systems is the addition of a truck-mounted tender unit to deliver fertilizer material directly to the spreading site. The addition of this tender equipment would allow the applicator to operate farther from headquarters. The manufacturers of truck-mounted tenders interviewed constructed notably analogous units, which consisted primarily of two compartments with rear discharge and side discharge available on most models. These units were powered by a PTO-operated, hydraulic pump, and hopper units were constructed of stainless steel with stainless steel augers. Available options or upgrades include engine front mount hydraulic pumps and multiple compartments.

Another difference noted among manufacturers was the availability of alternative truck chassis. Manufacturers are remarkably flexible in terms of cooperation when dealing with customers on these issues. Most manufacturers interviewed offered high-quality, used, reconditioned truck chassis and modified this chassis to fit their respective tender units. The modification normally consists of lengthening the frame and drive shaft. These truck chassis are typically fleet-maintained vehicles from various local vendors, such as delivery or food vendors, and the manufacturer of the tender has confidence that the vehicles are sound and reliable. These manufacturers also offer to purchase a new truck chassis, per customer specification, for installation of tender unit. An additional alternative for customers who currently own tender truck is to trade tender beds, trucks, or any combination of the procedures described previously. The additional equipment requires one laborer to operate the tender.

For purposes of this study, the purchase of a new truck chassis and new tender body was assumed. The estimated average list price for the System 2 applicator is identical to that of System 1 and was presented in Table 2. Table 5 contains observations and an estimated average list price for tender units, with a new truck chassis and a new tender body as described. Table 6 contains the estimated initial investment cost for System 2. Table 7 represents estimated daily and annual costs and returns for System 2. Estimated gross revenue is based on assumed days and hours of operation given in Table 1. Costs included are for the first year only. The spreading applicator was assumed to operate 10 hours per day and the tender equipment 12 hours per day. Charges for repairs and maintenance are the only changes that make costs different in the remaining 9 years of assumed useful life. These changes are reflected in estimated net revenue calculations presented in the results.

Table 5. Individual observations and average list prices for truck-mounted tender equipment.

Observation	New tender bed	New truck chassis	New truck tender
	$	*$*	*$*
1	17,500	77,500	95,000
2	11,825	77,500	89,325
Average[1]	14,663	77,500	92,163

[1]List price does not include any dealer discounts or promotions.

Table 6. Initial investment for System 2.

Item	Amount
	$
Conventional spin-spreader applicator	68,115
Tender truck and bed	92,163
Total	**160,278**

Table 7. Operation costs and returns for System 2, Year 1.

Item (unit)	Quantity units/hour	Price per unit	Amount per hour	Amount per day	Amount Period 1	Period 2	Period 3	Period 4	Total
		$	$	$	$	$	$	$	$
Income:									
Spreading (acre)	50.00	3.25	162.50	1,625.00	4,875	36,595	19,305	36,684	97,459
Expenses:									
Spreader –									
Fuel (gal)	8.50	1.20	10.20	122.40	367	2,756	1,454	2,763	7,340
Labor ($)	1.00	10.00	10.00	120.00	360	2,702	1,426	2,709	7,197
Repair & maint. (hr)	1.00	3.79	3.79	37.86	114	853	450	855	2,270
Tender Truck –									
Fuel (gal)	3.50	1.20	4.20	50.40	151	1,135	599	1,138	3,022
Labor ($)	1.00	8.00	8.00	96.00	288	2,162	1,140	2,167	5,757
Repair & maint. (hr)	1.00	4.27	4.27	51.22	154	1,154	609	1,156	3,072
Total cost			**40.45**	**477.88**	**1,434**	**10,762**	**5,677**	**10,788**	**28,661**
Net revenue					**3,441**	**25,833**	**13,628**	**25,896**	**68,798**

There are many manufacturers of conventional, single-bin, pneumatic boom applicators, and each has its own unique features. However, the fundamental design of the actual applicator beds has many similarities. One type of chassis used for mounting the applicator is the high-flotation, truck-type frame available in either two- or four-wheel drive and with engine horsepower ranging from 300 to 400. The high-flotation chassis are constructed of tubular steel with few welded joints to allow the chassis increased flexibility under adverse conditions and maximum loads. This applicator typically comes equipped with a heavy-duty automatic or power shift transmission. The boom length ranges from 60 to 70 feet. Table 8 provides observations and estimated industry average list prices for the various types of single-bin, pneumatic applicators.

The conventional truck frame applicator begins with a standard, diesel-powered, 2-ton or larger truck with a horsepower range of 250 to 400. The standard truck chassis is typically ordered from the manufacturer with a heavy-duty automatic transmission and heavy-duty front and rear axles. Four-wheel drive and

Table 8. Individual observations and average list prices for single-bin, pneumatic applicators.

Observation	Single-bin pneumatic applicator	Boom width	Engine horsepower
	$	ft	hp
1	248,675	70	300
2	222,225	70	300
3	256,275	70	400
4	252,600	70	400
5	224,550	70	300
6	256,275	70	400
7	222,225	70	300
Average [1]	240,404		

[1]List prices of these applicators includes controller and parallel swathing system. These list prices do not reflect any dealer discounts or promotions.

a manual transmission are available as options and have been utilized for specific applications, but they are not commonly found. The most common boom length for this applicator is 60 to 70 feet.

This type of applicator is also hydraulically powered with a direct engine-mounted pump, rather than PTO. The applicator consists of a material box that is typically stainless steel and designed to apply one type of fertilizer, whether single element or blended material. The bin discharges out the bottom through a metering door or gate onto a conveyor belt to move the material to the collection point at the boom. The distribution systems vary slightly due to patented processes and designs, but they generally consist of a series of tubes mounted in front of a fan that generates extreme airflow. The fertilizer material is discharged from the end of the conveyor into this fan assembly and enters the boom.

The boom is constructed of stacked hollow tubing, which increases in length from the top downward. The tubes are connected to the collection point at the fans with flexible tubing to allow fertilizer material to reach the final discharge point, as well as boom fold for transport. This design allows evenly spaced fertilizer material outlets and consistent spread width and pattern. Distribution and discharge methods are dependent on proprietary design. It should be noted that some equipment manufacturers offer rear mount or midship placement of the boom, thus the conveyor discharge point could change.

The control systems of these applicators are very similar, and in some cases, identical to those used on the spin-spreader applicators. These control systems must monitor and synchronize ground speed and conveyor speed to control fertilizer output and obtain proper fertilizer application. This is accomplished by varying the speed of hydraulic motors. One common accessory typically found with this system is a herbicide application kit. This addition allows simultaneous application of herbicide and burndown chemical with fertilizer material. Another function of this system is a seeding procedure, such as winter wheat or rice. These procedures are not included in the cost component of the study.

For purposes of this study, it was assumed that one Class A truck and two, two-compartment tender trailers are utilized to maintain fertilizer material supply to the applicator throughout the day. The truck and tender trailers require one additional laborer for operation.

Class A Trucks

The Class A trucks engaged in dispatching tender trailers are standard diesel truck chassis with a minimum 40,000-pound rear-drive axle. These trucks usually have twin-screw drive axles as operation in marginal conditions is quite common. Some of the interviews conducted revealed that used, reconditioned, fleet-maintained vehicles were purchased for these operations. This is a common practice among smaller vendors and applicators, but some larger vendors prefer to purchase new truck chassis per company specifications.

For purposes of this study, the purchase of new Class A truck chassis and new tender trailers was assumed. Table 9 contains observations and the industry average list prices for new Class A truck chassis.

Table 9. Individual observations and average list prices for Class A trucks and trailer-mounted tender equipment.

Observation	Tender trailer capacity	Tender trailer	Engine upgrade option	Side-discharge option	Stainless steel auger	New Class A truck chassis	Tender unit with new truck chassis
	tons	*$*	*$*	*$*	*$*	*$*	*$*
1 [1]	24	36,000	2,000			90,000	128,000
2 [2]	27	31,725	2,000	2,250		90,000	125,975
3 [3]	32	40,400				90,000	130,400
4 [4]	25	31,930	2,600		1,200	90,000	125,730
Average						90,000	127,526

[1]List price includes stainless steel auger and side-discharge option.
[2]List price includes stainless steel auger.
[3]List price includes engine upgrade, side discharge, and stainless steel auger.
[4]Manufacturer does not yet offer side discharge on this model.

Trailer-Mounted Tenders

These tender trailers come standard with an air-cooled engine and self-contained hydraulics. The tender trailers included in this study were equipped with air-cooled engines, as well as diesel, water-cooled engines offered as an option by the manufacturer. This upgrade is popular among vendors and applicators as the diesel engine is more powerful and has a longer expected life.

The self-contained hydraulics enable detaching the trailer at the field location and routing the truck to another location. This permits one truck to manipulate two tender trailers in an attempt to sustain fertilizer supply to the single-bin applicator. It should be noted that availability of fertilizer materials applied, distance from fertilizer terminal or stock, size and location of field, amount of fertilizer materials applied, applicator loading time, and any breakdown or downtime will affect the efficiency of the tender equipment described.

Table 10 contains initial investment costs assumed for System 3. Estimated first year costs and returns for System 3 are given in Table 11. Costs included for the first year are based on assumed days and hours of operation. Applicator equipment was assumed to operate 10 hours per day, while tender equipment was assumed to work 12 hours per day. Charges for repair and maintenance in the later years are the only changes that impact costs in the remaining 9 years of assumed useful life. These changes are reflected in net revenue calculations presented in the results.

Table 10. Initial investment cost for System 3.

Item	Amount
	$
Single-bin pneumatic applicator	240,404
Class A truck and tender trailer	127,526
Extra tender trailer	37,526
Total	**405,456**

Table 11. Operation costs and returns for System 3, Year 1.

Item (unit)	Quantity units/hour	Price per unit	Amount per hour	Amount per day	Amount Period 1	Period 2	Period 3	Period 4	Total
		$	$	$	$	$	$	$	$
Income:									
Spreading (acre)	75.00	4.10	307.50	3075.00	9,225	69,249	36,531	69,418	184,423
Expenses:									
Spreader –									
Fuel (gal)	8.50	1.20	10.20	122.40	367	2,756	1,454	2,763	7,341
Labor (hr)	1.00	10.00	10.00	120.00	360	2,702	1,426	2,709	7,197
Repairs & maint. (hr)	1.00	13.36	13.36	133.61	401	3,009	1,587	3,016	8,013
Class A Truck (each) –									
Fuel (gal)	3.50	1.20	4.20	50.40	151	1,135	599	1,138	3,023
Labor (hr)	1.00	8.00	8.00	96.00	288	2,162	1,140	2,167	5,758
Repairs & maint. (hr)	1.00	4.17	4.17	50.02	150	1,126	594	1,129	3,000
2 Tender Trailers –									
Fuel (gal)	2.50	1.20	3.00	36.00	108	811	428	813	2,159
Repairs & maint. (hr)	1.00	3.48	3.48	41.71	125	939	496	942	2,502
Total costs			**56.41**	**650.15**	**1,950**	**14,641**	**7,724**	**14,677**	**38,993**
Net revenue					**7,275**	**54,608**	**28,807**	**54,741**	**145,431**

There are also several manufacturers of multibin, pneumatic applicators. While each applicator has unique features and standards, the fundamental design of the applicators are similar. The truck chassis available for mounting this applicator are identical to the chassis described previously for the single-bin, pneumatic applicator and have the same available options and accessories.

Costs for multibin, pneumatic applicators are given in Table 12. The multibin, pneumatic applicator can be operated in one of three application scenarios: conventional broadcast application, variable-rate application, and blend on-the-go application.

Table 12. Individual observations and average list prices for multibin, pneumatic applicators.

Observation	List price	Boom width	Engine horsepower
	$	*ft*	*hp*
1	299,325	70	400
2	271,275	70	300
3	280,770	70	400
4	246,720	70	300
5	258,520	70	300
6	325,000	70	400
7	265,000	70	400
Average [1]	278,087		

[1]List prices include controller, GPS unit, all applicable software and hardware, telephone technical support, parallel swathing system, and free training for two employees. List prices do not reflect any dealer discounts or promotions.

The multibin applicator is hydraulically powered with a direct engine-mounted pump, rather than PTO. The applicator consists of a stainless-steel, two-compartment material box designed to apply two types of fertilizer, typically single-element materials. The discharge and metering systems on the multibin unit differ from the single-bin unit described previously only in number of material outlets and the two types of applicators are usually manufactured by the same vendors. Table 12 contains average prices for the various multibin, pneumatic applicators.

Variable-Rate Application

The variable-rate application consists of several components. The most essential elements are the electronics systems, which control the actual application sequence.

The controllers used in the multibin, pneumatic applicators are more complex than the control systems on other applicators. These controllers are capable of interfacing with a GPS unit to promote variable-rate application using location data. The variable-rate application also requires a prescription map, which is a fundamental component of a variable-rate program. A prescription map essentially consists of data on variability in soil properties, historical yield, and historical knowledge of fields. Intensive soil sampling and data from agricultural consultants provide vital data for the development of the prescription map. Producer knowledge of their respective fields is also an important component to the development of a prescription. The producer may have some insight about particular areas of a field that typically yield low or high, and this information can be passed on to consultants or vendors for inclusion in the final prescription.

Prescription maps typically define the respective fields into management zones, where variability is defined based on the appropriate data. The soil sampling procedure provides geo-referenced points, which are entered into the desktop computer using Geographic Information Systems (GIS) software. GIS software is a database format product offered by numerous commercial vendors and developers. The software is designed for data analysis, visualization, presentation, and planning. The software processes the available data using algorithms to interpolate management zones. These zones appear as polygons on the computer screen and have known coordinates associated with their boundaries.

The prescription is copied to a portable storage device, usually a Personal Computer Memory Card International Association card (PCMCIA card) and installed in the controller. Once the prescription map is complete and loaded into the controller, the applicator is field-ready. As the applicator moves across the field, the controller interprets the data on the prescription map using location data from the GPS unit and adjusts the rate of application. This adjustment is achieved by varying the speed of hydraulic motors and size of openings in metering doors on the compartments. The resulting application provides placement of nutrients where most beneficial, based on variability within the field. The controller is also capable of printing "as-applied" maps to the portable storage device. These maps illustrate the material application applied in variable fashion in a database format for future analysis using the GIS software.

It should be noted that software, controllers, and any other associated hardware must be fully compatible. The manufacturer usually provides all equipment, accessories, and limited training, but installation on an existing multibin applicator requires close scrutiny of these issues. Another consideration is the amount and availability of fertilizer material being applied and the available tender equipment. In cases where large quantities of one element and smaller quantities of another element are applied, tender equipment may not be capable of maintaining fertilizer supply to the applicator. Other considerations include distance to terminal or stockpile of fertilizer material, size of field, total acreage to cover during a specified time period, and any breakdown or other downtime.

Blend On-the-Go

The application equipment for on-the-go blending is identical to the equipment outlined in the previous section. The primary difference is in the manner of application.

The blend on-the-go application procedure may be accomplished with or without a prescription map. The applicator can simply spread a constant rate of two fertilizer materials according to the producer's instructions. This allows the vendor to transport fertilizer material directly from the terminal or stockpile to the field. This practice reduces handling of the material and eliminates mixing at the vendor headquarters.

Table 13. Initial investment cost for System 4.

Item	Amount
	$
Multibin pneumatic applicator	278,087
Class A trucks - 2 units	180,000
Tender trailers - 3 units	111,768
Total	**569,855**

Table 14. Operation costs and returns for System 4, Year 1.

Item (unit)	Quantity units/hour	Price per unit	Amount per hour	Amount per day	Amount Period 1	Amount Period 2	Amount Period 3	Amount Period 4	Amount Total
		$	$	$	$	$	$	$	$
Income:									
Variable rate, 20% (acre)	15.00	7.80	117.00	1,170.00	3,510	26,348	13,900	26,413	70,171
Blend on-the-go, 20% (acre)	15.00	6.20	93.00	930.00	2,790	20,944	11,048	20,995	55,777
Broadcast, 60% (acre)	45.00	4.10	184.50	1,845.00	5,535	41,549	21,919	41,651	110,654
Totals	**75.00**			**3,945.00**	**11,835**	**88,841**	**46,867**	**89,058**	**236,601**
Expenses:									
Multibin Pneumatic Applicator –									
Fuel (gal)	8.50	1.20	10.20	122.40	367	2,756	1,454	2,763	7,341
Labor (hr)	1.00	10.00	10.00	120.00	360	2,702	1,426	2,709	7,197
Repairs & maint. (hr)	1.00	15.46	15.46	154.56	464	3,481	1,836	3,489	9,270
Class A Truck (2 units) –									
Fuel (gal)	3.50	1.20	8.40	100.80	302	2,270	1,198	2,276	6,045
Labor (hr)	1.00	8.00	16.00	192.00	576	4,324	2,281	4,334	11,515
Repairs & maint. (hr)	1.00	8.34	8.34	100.04	300	2,253	1,188	2,258	6,000
Tender Trailers (3 units) –									
Fuel (gal)	2.50	1.20	9.00	108.00	324	2,432	1,283	2,438	6,477
Repairs & maint. (hr)	1.00	5.21	5.21	62.57	188	1,409	743	1,413	3,753
Total costs			**82.61**	**960.37**	**2,881**	**21,628**	**11,409**	**21,680**	**57,598**
Net revenue					**8,954**	**67,214**	**35,457**	**67,378**	**179,003**

The vendor may also soil sample the field and develop a prescription map for the elements required. This prescription map is analogous in design and development to the map described for the variable-rate application procedure. This also reduces handling of material and eliminates mixing of materials, but it could cause some logistical problems. Should the prescription developed require large quantities of one element and smaller quantities of another, tender equipment could become overladen attempting to supply sufficient fertilizer material to the applicator. This would be determined in part by distance to the fertilizer supply, size of field, amounts and availability of fertilizer materials applied, and amount of total acreage to cover in a given time period. Breakdowns and other downtime, such as applicator loading, should also be taken into consideration.

Conventional Broadcast Application

Due to limited demand for variable-rate and blend on-the-go applications, the multibin, pneumatic applicator is utilized as a conventional broadcast applicator when necessary. The applicator is used in this manner to prevent the machine from remaining idle and to satisfy conventional fertilizer application demands. It is assumed in this study that a percentage of the application with this applicator is conventional broadcast. This percentage varies according to vendor market territory and market share.

Total amount of time available for applying fertilizer during any period is also a major contributing factor to the use of this applicator in a conventional manner. For analysis purposes, it was assumed that 60% operation is conventional broadcast, 20% operation is variable rate, and the remaining 20% operation is blend on the go. This applicator may also be equipped with the herbicide application kit described above for System 3. Likewise, this applicator may be utilized for seeding operations. However, these components are not included in the cost component of this study.

For purposes of this study, it was assumed that two Class A trucks and three two-compartment tender trailers are utilized to maintain fertilizer material supply to the applicator throughout the day. The trucks and their tender trailers require two additional laborers for operation. The Class A trucks and tender trailers are identical to the equipment described for System 3. The number of tender trailers required to sustain one multibin applicator may vary and is dependent, in part, upon availability of fertilizer materials applied, distance from fertilizer terminal or stock, size and location of field, amount of various fertilizer materials applied, applicator loading time and any breakdown or downtime. Table 13 contains initial investment costs for System 4. Table 14 contains annual cost and return information for System 4. Estimated gross revenue included in Table 14 is based on assumed days and hours of operation. Costs and returns are included for the first year only based on assumed days and hours of operation. Charges for repair and maintenance are the only changes that impact costs in the remaining 9 years of assumed useful life. These changes will be reflected in net revenue calculations presented in the results.

Net Present Value Analysis

Investment analysis, sometimes called capital budgeting, was used to determine a potential investment's profitability or compare two or more investment's profitability. Several alternative investment methods exist, but a preferred technique is the net present value method. The net present value method requires data on (1) initial cost, (2) the annual net cash revenues, (3) the terminal or salvage value of the investment, and (4) the discount rate or interest rate. In this approach, the investment's net present value is the sum of the present values of each year's net cash revenue minus the initial investment cost. The net present value calculation can be written:

$$NPV = \frac{P_1}{(1+i)^1} + \frac{P_2}{(1+i)^2} + ... + \frac{P_n}{(1+i)^n} - C$$

where: NPV = net present value of the investment,
P_n = is the net revenue in period n,
i = periodic discount rate,
n = period, and
C = cost of the investment.

The net present value approach takes both the time value of money and the size of the net revenue stream over the life of the investment into consideration. The terminal, or salvage value, is usually included in the last year's revenue stream.

Investments with a positive NPV would be deemed acceptable, while those with negative NPV would be rejected. Positive NPVs indicate the return on investment is higher than the discount rate. In this study, the discount rate was assumed to be 10%.

The various application systems were analyzed using the net revenue streams presented in Section 3. The estimated first-year cost and return for each system were presented previously. The remaining years' nominal net revenue streams differ only slightly because of the assumption regarding repair charges discussed in a previous section. The following tables for each system contain 10-year quarterly estimated net returns along with the present value of net returns. The tables also indicate differences between discounted present value of net revenue and initial investment cost. Additionally, the difference is annualized by dividing by 10.

The conventional spin-spreader system consists solely of a spin-spreader applicator. This system is common in all non-Delta regions of the state. The applicator typically loads at the headquarters, travels to the field to apply fertilizer, and then returns to the headquarters to reload. It was assumed that this applicator covered 35 acres per hour operating in this manner. It was also assumed that this applicator operated 10 hours per day with downtime for travel and reloading. This operating time is based on the assumption that this applicator would work in close proximity to the headquarters and travel time would be minimal. Table 15 provides estimated net revenue by quarter and the present value of the net revenue stream generated by this system. The difference between estimated initial investment costs of $68,115 and present value of net revenue is $245,638 for the 10-year useful life, or $24,564 on an average annual basis. This difference represents the estimated discounted net returns in excess of initial investment cost.

Table 15. Estimated net revenue by period and estimated present value of revenue stream, System 1.

Years 1 through 3			Years 4 through 6			Years 7 through 10		
Period	Net revenue	PV net revenue	Period	Net revenue	PV net revenue	Period	Net revenue	PV net revenue
1	2,572	2,509	13	2,515	1,824	25	2,472	1,334
2	19,305	18,375	14	18,879	13,361	26	18,559	9,766
3	10,184	9,457	15	9,959	6,876	27	9,791	5,026
4	19,352	17,532	16	18,925	12,748	28	18,604	9,319
5	2,572	2,273	17	2,515	1,653	29	2,472	1,208
6	19,305	16,647	18	18,879	12,104	30	18,559	8,848
7	10,184	8,567	19	9,959	6,230	31	9,791	4,554
8	19,352	15,883	20	18,925	11,549	32	18,604	8,442
9	2,572	2,059	21	2,515	1,497	33	2,472	1,095
10	19,305	15,081	22	18,879	10,966	34	18,559	8,016
11	10,184	7,762	23	9,959	5,644	35	9,791	4,125
12	19,352	14,389	24	18,925	10,463	36	18,604	7,648
						37	2,472	992
						38	18,559	7,262
						39	9,791	3,737
						40	18,604	6,929
Total PV net revenue								**313,753**
Initial investment								**68,115**
Net PV								**245,638**
Average NPV								**24,564**

The conventional spin-spreader systems for the Delta consist of a spin-spreader applicator and a truck-mounted tender. Similar systems are found in other regions however. This system allows the applicator to cover more acres per day with the tender delivering fertilizer material directly to the field. It was assumed that this system would cover 50 acres per hour. Further assumptions included operating the tender equipment 12 hours per day and operating the applicator 10 hours per day due to travel and reloading downtime. This system was assumed to operate further from headquarters with the addition of the truck-mounted tender. Table 16 provides estimated net revenue by quarter and the net present values of the net revenue stream generated by this system. The difference between estimated initial investment costs of $160,277 and present value of net revenue is $238,121 for the 10-year useful life, or $23,812 on an average annual basis. This difference represents the estimated net returns in excess of initial investment cost.

Table 16. Estimated net revenue by period and estimated net present value of revenue stream, System 2.

Years 1 through 3			Years 4 through 6			Years 7 through 10		
Period	Net revenue	PV net revenue	Period	Net revenue	PV net revenue	Period	Net revenue	PV net revenue
1	3,441	3,357	13	3,308	2,400	25	3,208	1,730
2	25,833	24,588	14	24,830	17,573	26	24,078	12,671
3	13,628	12,655	15	13,099	9,044	27	12,702	6,521
4	25,896	23,461	16	24,891	16,767	28	24,137	12,089
5	3,079	2,721	17	3,308	2,174	29	3,208	1,567
6	22,605	19,492	18	24,830	15,920	30	24,078	11,479
7	11,662	9,811	19	13,099	8,194	31	12,702	5,908
8	21,674	17,788	20	24,891	15,190	32	24,137	10,952
9	3,079	2,465	21	3,308	1,969	33	3,208	1,420
10	22,605	17,659	22	24,830	14,423	34	24,078	10,399
11	11,662	8,888	23	13,099	7,423	35	12,702	5,352
12	21,674	16,115	24	24,891	13,761	36	24,137	9,922
						37	3,208	1,286
						38	24,078	9,421
						39	12,702	4,849
						40	24,137	8,989
Total PV net revenue								**398,398**
Initial investment								**160,277**
Net PV								**238,121**
Average NPV								**23,812**

This system consists of a single-bin, pneumatic applicator; one Class A truck; and two two-compartment tender trailers. This system is assumed to cover a minimum of 75 acres per hour with the tender equipment delivering fertilizer material directly to the application site. One of the most common accessories for this system is a herbicide application kit. This allows application of herbicide or burndown chemicals simultaneously with fertilizer. This applicator is also utilized for seeding purposes, such as winter wheat or rice. For purposes of this study, neither the herbicide kit nor the seeding procedure were included in the cost component. Table 17 indicates estimated net returns and estimated present values of the revenue stream generated by this system. The difference between estimated initial investment costs of $405,456 and the present value of net revenue is $455,316 for the 10-year useful life, or $45,532 on an average annual basis. This difference represents the estimated net returns in excess of initial investment cost.

Table 17. Estimated net revenue by period and estimated net present value of revenue stream, System 3.

Years 1 through 3			Years 4 through 6			Years 7 through 10		
Period	Net revenue	PV net revenue	Period	Net revenue	PV net revenue	Period	Net revenue	PV net revenue
1	7,275	7,097	13	6,937	5,032	25	6,432	3,470
2	54,608	51,976	14	52,070	36,852	26	48,287	25,410
3	28,807	26,750	15	27,469	18,966	27	25,473	13,078
4	54,741	49,593	16	52,197	35,161	28	48,405	24,245
5	7,275	6,430	17	6,937	4,559	29	6,432	3,143
6	54,608	47,088	18	52,070	33,386	30	48,287	23,020
7	28,807	24,235	19	27,469	17,182	31	25,473	11,848
8	54,741	44,929	20	52,197	31,855	32	48,405	21,965
9	7,275	5,825	21	6,937	4,130	33	6,432	2,848
10	54,608	42,659	22	52,070	30,246	34	48,287	20,855
11	28,807	21,955	23	27,469	15,566	35	25,473	10,733
12	54,741	40,703	24	52,197	28,859	36	48,405	19,899
						37	6,432	2,580
						38	48,287	18,894
						39	25,473	9,724
						40	48,405	18,027
Total PV net revenue								**860,772**
Initial investment								**405,456**
Net PV								**455,316**
Average NPV								**45,532**

This system consists of one multibin, pneumatic applicator; two Class A trucks; and three two-compartment tender trailers. This system is assumed to cover 75 acres per hour with the tender equipment delivering fertilizer material directly to the application site. The applicator is assumed to operate 10 hours per day, due to travel and loading time, and the tender equipment assumed to operate 12 hours per day. This system is capable of being equipped with the herbicide accessory described in System 3, as well as utilization for seeding procedures. These additional procedures are not included in the cost component of the study. Table 18 indicates estimated net returns and estimated present values of the revenue stream generated by this system. The difference between estimated initial investment costs of $569,855 and the present value of the estimated net revenue is $426,927 for the 10-year useful life, or $42,693 on an average annual basis. This difference represents the estimated net returns in excess of initial investment cost.

Table 18. Estimated net revenue by period and estimated net present value of revenue stream, System 4.								
Years 1 through 3			Years 4 through 6			Years 7 through 10		
Period	Net revenue	PV net revenue	Period	Net revenue	PV net revenue	Period	Net revenue	PV net revenue
1	8,954	8,736	13	8,478	6,150	25	8,121	4,381
2	67,214	63,975	14	63,643	45,042	26	60,964	32,081
3	35,457	32,926	15	33,573	23,181	27	32,160	16,511
4	67,378	61,041	16	63,798	42,976	28	61,113	30,610
5	7,170	6,337	17	8,478	5,572	29	8,121	3,969
6	52,507	45,277	18	63,643	40,805	30	60,964	29,064
7	27,024	22,734	19	33,573	21,001	31	32,160	14,958
8	50,099	41,119	20	63,798	38,934	32	61,113	27,731
9	7,170	5,741	21	8,478	5,048	33	8,121	3,595
10	52,507	41,019	22	63,643	36,968	34	60,964	26,331
11	27,024	20,596	23	33,573	19,026	35	32,160	13,551
12	50,099	37,252	24	63,798	35,272	36	61,113	25,123
						37	8,121	3,257
						38	60,964	23,854
						39	32,160	12,277
						40	61,113	22,760
Total PV net revenue								**996,782**
Initial investment								**569,855**
Net PV								**426,927**
Average NPV								**42,693**

Breakeven Analysis

Demand for spreading services and market share are major considerations. Investors are likely to be interested in the minimum number of days of operation or acres necessary for discounted net revenue to equate to initial investment cost. In this analysis, therefore, number of days of operation was parameterized and "breakeven" days and acres were calculated. The breakeven number of days was calculated for each system using the same cost and returns procedures presented previously. The breakeven analysis carries with it the implication that the investment will make a return equal to the discount rate, 10%. The breakeven number of days for each system is presented in Table 19.

System 1 would require an estimated 15.8 days of operation per year to break even. Given the assumptions about daily acreage covered by each system, this also means that System 1 would have to cover 5,227 acres annually to break even. System 2 would require 27.8 days to break even, covering 13,903 acres each year; System 3, 32.3 days, 24,242 acres; and System 4, 37.8 days, 28,367 acres.

Table 19. Estimated breakeven annual days of operation and corresponding acreage, by system.						
Item	**Period 1**	**Period 2**	**Period 3**	**Period 4**	**Total breakeven days of operation**	**Total breakeven acres**
Originally assumed days of operation	3.00	22.52	11.88	22.58		
Percentage of total days suitable	20%	40%	20%	35%		
Breakeven days of operation:						
System 1	.8	5.9	3.1	6.0	15.8	5,527
System 2	1.4	10.4	5.5	10.5	27.8	13,903
System 3	1.6	12.1	6.4	12.2	32.3	24,242
System 4	1.9	14.2	7.5	14.2	37.8	28,367

Conclusions and Limitations

The estimates of net revenue and net present value of revenue streams for all systems indicate investments are feasible under the assumption of 100% equity capital. Reduced equity positions will reduce NPVs and will increase breakeven days of operation and breakeven acreage requirements when additional costs are incurred to borrow funds. However, NPVs are sufficiently high so as to accommodate considerable leverage and still remain feasible.

Market territory, market share, and prices charged by vendors and custom applicators will affect investment decisions. Acreage coverage per hour assumptions, which will vary among vendors and custom applicators, will also affect income projections. Labor costs and equipment costs will vary among investors and will impact cost calculations. The underlying assumptions were intended to be conservative and provide guidelines for potential investors. These data are not intended to represent industry or statewide average scenarios or charges. The authors collected data where possible.

There are some variations in the number of observations of equipment described in this study. A standard set of equipment was assumed for each system and included equipment observed as most frequently used. This standard set of equipment does not include every piece of equipment actually used in fertilizer application, so some equipment may not be represented.

It should be noted again that all estimates of costs are based on the assumption of 100% equity capital and zero salvage value. There are no provisions for loan amortization, interest costs, taxes, or a positive salvage value. Traditional concepts of NPV investment analysis apply. Even though equity capital is assumed, alternative investment opportunities are always possible. Further analysis is required for investment where all or some portion of the initial investment cost must be secured from other sources and amortized. Analysis methods such as internal rate of return and payback period could also be used to assist in decision making. The spreadsheets developed for this study could be modified to reflect alternative parameter and equity scenarios for particular investors. These spreadsheets will be made available upon request for further analysis.

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