COST, CAPACITY AND MANAGEMENT OF FORAGE HARVESTING, HANDLING AND STORAGE SYSTEMS

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The severe shortage of reliable labor and the increasing cost for skilled farm labor is having an impact on forage systems used on beef cattle farms and dairies. Due to these labor problems, the use of the traditional baling system is decreasing. In addition, many hay growers are desiring new hay systems that will lower harvesting and handling costs, ease management, maintain quality, and provide opportunity to harvest and store increased tonnages. Types of hay harvesting and handling equipment being considered to meet these criteria are automatic bale wagons, loose hay stack wagons, and roll balers.

Another forage system receiving consideration is silage. Silage is a low-labor forage that is stored at high moisture. Silage properly preserved can yield a greater dry matter quantity and higher quality of feedstuff compared to harvesting the crop for hay. However, it is essential to remember that a large percentage of silage is water, which dictates that greater handling capacity is required than for an equivalent amount of hay. Even with the higher moisture content, the required storage space per dry matter unit can be less by 50 percent compared to baled hay. It is also possible to harvest and store silage during less favorable weather conditions than for hay harvesting, thus conserving quality.

COST ANALYSIS

All costs for field equipment were determined in accordance with the American Society of Agricultural Engineers Data. Costs included in this analysis were both fixed and operating costs. Calculated fixed costs include depreciation, interest on investment, taxes, insurance, and shelter. The depreciation schedule was assumed to be a declining balance. Operating costs included labor, fuel, lubrication, and repairs.

Fuel costs were assumed to be $.40 per gallon for diesel fuel and $.45 per gallon for regular gasoline. A labor charge of $3 per hour concurs with the normal rate for operating hay equipment in Oklahoma. Hay equipment requiring tractor power is charged for a tractor that matches the system. It was assumed that all tractors were diesel and had an annual use of 600 hours with a 10-year life.

Lifetime of hay and silage equipment is primarily dependent upon the design of the machinery, annual use, field conditions, operator skill, management, and proper maintenance. Operating conditions for hay equipment in Oklahoma range from mild to severe; therefore, the reliable life is variable. Estimated reliable life in hours and obsolescence life in years for forage equipment operating in Oklahoma are shown in Table I. When calculating the costs for hay equipment, the life of the machine was assumed to be eight years (obsolescence life) or the riliability life, whichever occurs first. Costs for individual forage machine operations shown in Tables II and III are based on the preceding assumptions.

Storage costs for hay and silage are included in Table IV. Expected life for each type of storage structure is listed in the table.

CAPACITIES AND LABOR REQUIREMENTS

Typical capacities and the corresponding labor requirements for hay and silage equipment operating in Oklahoma are tabulated in Tables V and VI. These capacities are based on observations made throughout the state; therefore, a wide range of field conditions, operator skills, and equipment conditions were encountered. However, the field observations also indicated that the capacities for most individual operations were within 25 percent of the tabulated values. In other words, with ideal operating conditions, the actual capacities could exceed the tabulated capacities by 25 percent and with poor operating conditions, the actual capacities could be 25 percent less than the capacities listed.

TRADITIONAL BALING SYSTEM

Production of two wire bales that are hand hauled to storage and feeding is the most commonly used hay system in Oklahoma. The field equipment normally used to produce the bales are a windrower, rake, baler, and tractor. The hand hauling to storage is primarily a custom operation charged at a rate of $.15 to $.30 per bale. The feeding of the bales is usually accomplished by hauling bales from a storage area to the feeding area with a pickup truck.

Some farms in Oklahoma employ custom hay operators to windrow, rake, bale, and haul the bales to storage. The management decision to use custom hay operators instead of purchasing and operating hay equipment is normally based on economics. The least cost for the traditional bale system is with custom hay harvesting, packaging, and handling for an annual production of 175 tons or less and owning and operating hay equipment for annual tonnages exceeding 175 tons. The custom rate for windrowing, raking, and baling varies considerably within Oklahoma; however, for small annual tonnages (175 tons or less) $18 per ton is not unusual. This custom rate combined with custom hauling to storage ($7.50 per ton) and feeding bales ($6.25 per ton) maintains the cost for harvesting and handling baled hay to over $31 per ton on small operations. Some cow-calf operators are willing to pay even more and own equipment for the convenience and capability to bale hay under proper conditions for highest quality. Custom operators are frequently busy when the hay needs to be harvested and hauled to storage, thus a decrease in quality of the stored hay.

The costs for owning and operating the equipment in a traditional baled hay system are tabulated in Table II. The costs for owning and operating the traditional baled hay system, as with any hay system, will decrease as annual production increases until inefficiencies occur because of equipment overload. However, it should also be noted that increasing the annual production over 600 tons does not reduce the costs substantially because the effect of annual machinery fixed costs is small compared to the high labor requirement, wire cost, and other operating costs. The costs in Table II point out the fact that traditional baled hay methods have a minimum cost barrier of approximately $25 per ton just to put hay into storage.

The use of the traditional baling system is decreasing because custom haulers and laborers are becoming increasingly difficult to employ. The self-propelled bale handler helps alleviate the problem with increased capacity; however, three men are still needed to operate the handler efficiently. The labor requirements for the traditional bale system from harvest through feeding are nearly 2.5 man-hours per ton. With a high labor requirement, growth is limited and excellent management is needed to achieve the highest quality hay. However, this system still provides the least cost for production levels of less than 100 tons per year. It also has the advantages that the product can be economically hauled long distances, and custom balers are readily available in most areas.

AUTOMATIC BALE WAGON SYSTEMS

The automatic bale wagon with one operator essentially replaces the two or three man crew field loading, hauling, and placing the bales in storage. The automatic bale wagons can be self-propelled or tractor powered. The smallest PTO automatic bale wagon (55 bales per load) is normally complemented with a PTO windrower (12 feet), a set of tandem rakes, heavy duty baler, and tractor. A larger PTO automatic bale wagon (104 bales per load) usually needs a windrower with greater capacity to match the system. A self-propelled windrower (14 feet) is an ideal match with the automatic bale wagon, a set of tandem rakes, heavy duty baler, and tractor. The self-propelled automatic bale wagon (160 bales per load) has the capacity to utilize two windrowers, two sets of tandem rakes, two heavy duty balers, and two tractors. The two windrowers are usually one self-propelled unit and one PTO model. The heavy duty balers are needed to handle the heavy windrows and produce a dense, uniform length bale, which the bale wagon can pick up and stack efficiently.

A cost comparison of the traditional baling system and the automatic bale wagon system reveals breakeven annual tonnages of approximately 250, 350, and 900 tons for the 55 bale PTO wagon, 104 bale PTO wagon, and 160 bale self-propelled wagon systems, respectively. The costs for each of the individual machine operations are included in Table II. Feeding costs for the automatic bale wagon systems are assumed to be equivalent to feeding costs for the traditional baling system. Even though some models have the capability to retrieve stacks and unload bales one at a time, feeding is normally conducted with a pickup truck. Also, most of the hay stacked with the self-propelled automatic bale wagons is sold and transported before feeding.

The use of the automatic bale wagon is limited because of the large annual breakeven tonnages. However, the substantial labor reduction can lead to increased production and provide an opportunity to acquire custom hauling and stacking. Typical labor requirements for the 55 bale PTO, 104 bale PTO, and 160 bale self-propelled automatic bale wagon systems from harvesting to storage are approximately 0.63, 0.55, and 0.49 man-hours per ton, respectively. The high capacity in the hauling and stacking operation can also increase the quality of hay be reducing weather damage in the field. This high quality can be preserved when the bales are properly stored; however, special storage structures are required to accept the bale wagon during unloading. To produce the highest quality hay and operate the system at maxi-

mum efficiency, the manager must be outstanding in coordinating all field operations. In addition, the bale wagon operator must be highly skilled and normally performs more efficiently when paid an incentive wage.

LOOSE HAY STACK WAGON SYSTEMS

The loose hay stack wagons are becoming increasingly popular with ranches and commercial hay farms located near a market. A variety of stack wagon types and sizes (1- to 8-ton stacks) are available. Most of the stack wagons currently used lift the windrow and convey it into an enclosed wagon. When the wagon is filled, the canopy is lowered to compress the loose hay. Other types of stack wagons were observed during field studies; however, these stack wagons are not used extensively in Oklahoma. The weight of the stack formed is dependent upon the materials stacked and capacity of the wagons; however, most stacks weigh approximately 1, 2.5, and 5 tons when formed with wagons that have a rated capacity of 1, 3, and 6 tons, respectively. The field equipment typically employed with the 1-ton stack wagon is a pull-type mower-conditioner (9 1/4 feet), stack mover, and tractor. The 3-ton stack wagon is usually accompanied with a pull-type mower-conditioner (12 feet), stack mover, and tractor. A self-propelled windrower (14 feet), stack mover, and tractor are normally used with the 6-ton stack wagon. On many farms a rake is only utilized to combine light windrows or to turn the hay during damp weather.

The breakeven annual tonnages for the 1, 3 and 6 ton loose hay stack wagon systems are 100, 150 and 250 tons compared to the traditional 2-wire baled hay system. This cost comparison includes feeding costs. Feeding costs for loose hay stacks are assumed to be the cost of moving a stack for one mile. Most loose hay stacks are moved on the farm only once to a combined storage and feeding area or directly to the feeding area. The costs for individual machine operations that are required with each of the systems are tabulated in Table II.

The loose hay stacks are not well suited for commercial hay growers unless the market is nearby. Most loose hay stacks moved on the roads are transported with a small truck and a stack mover that has a gooseneck trailer hitch or truck-mounted stack mover. The capacity of this hauling operation decreased rapidly with increased hauling distance. For example, when moving 5-ton stacks a distance of 10 miles, the capacity is approximately 7.0 tons per hour. However, when moving 5-ton stacks a distance of 25 miles, the capcity is reduced to about 3.3 tons per hour. Due to these low capacities, the fixed and operating costs for the hauling operation become extreme when the loose hay stacks are transported long distances. In addition, significant hay losses have been observed during on-road transportation of loose hay stacks. To prevent excessive hauling losses on the road, it is recommended that the top of the stack be secured with ropes or a net.

In addition to the harvesting cost savings, the purchase of stack wagons is further encouraged by the savings in labor and the feasibility of a one-man haying system. Typical labor requirements for the 1, 3, and 6 ton stack wagon systems from harvest through on-farm feeding are approximately 0.8, 0.6, and 0.4 man-hours per ton, respectively. In addition, the stack wagons offer flexibility in the capacity of stacking a wide variety of ma-

terials including alfalfa, grasses, straw, and even corn and milo stover. The stacks formed with a stack wagon are conducive to resisting weather; therefore, the hay requires no special storage. No special management techniques are required for efficient operation of the system, but experience in operation will improve the shape of the stacks formed and quality of hay stacked. Experience has indicated that loose hay stacks store best when stacked at a moisture content suitable for baling. Also, increased compaction during stack formation will reduce feeding losses when livestock feed on the stacks free choice.

The selection of loose hay stacking equipment is primarily dependent on cost and labor savings; however, the storage characteristics of the stacks formed should also be considered. When the loose hay stacks will be stored for three months or more, it is essential to have a well-shaped stack with a thatched sloping canopy to aid in shedding water. A dense stack normally has small spoilage losses. For a stack to resist wind and water damage, interlocking of hay within a stack is necessary. Also, maximum feeding benefits can be attained only when the hay is picked up cleanly from the windrow and handled gently to prevent leaf loss.

Custom rates for stacking hay with a loose hay stack wagon are typically $7 to $10 per ton. For this custom rate the stacks are normally unloaded directly in the field or nearby fence row. Custom hauling rates are variable with the distance.

ROLL BALING SYSTEMS

Roll baling is a haying concept used during the 1940's and 50's and being revitalized in the 1970's. However, instead of producing bales weighing 40 to 80 pounds, the large roll bales will weigh 1200 to 1500 pounds. The dimensions of the bales vary with equipment manufacturer and model, but are normally five to seven feet long and five to seven feet in diameter. Some roll balers produce a bale four feet long to facilitate more efficient loading for long distance transportation. The weight of the bales is dependent not only on dimensions but also on the type and quality of hay rolled into the bale.

Roll balers can be classified by the different features of each model. The most distinguishable feature is the method of rolling up the hay into a bale. One method of producing round bales is to pick up the hay from the windrow and roll the hay between a series of belts. The other method used to produce round bales is to roll the windorw on the ground, which is similar to rolling up a carpet. With either system, a typical complement of equipment is a pull-type windrower (12 feet), rake, roll baler, bale mover, and tractor. The rake is used primarily to produce a heavy windrow which aids in maximizing the production rate and in forming uniformly shaped bales. The bale mover is normally a two or three pronged fork, attached to the three-point hitch of a tractor. A front end loader is also used on many operations to lift and move roll bales. Multi-bale and single bale movers towed by a tractor or small truck are also used to haul roll bales from the field to storage and feeding.

excessive hay wastage results and damage occurs to the hay field, particularly during muddy conditions. To minimize feeding wastage with free choice feeding, feed only one package per feeding and force cleanup before feeding another package.

The daily feeding method reduces hay wastage but requires labor daily. The daily feeding can be accomplished by utilizing hay feeding equipment that unrolls big bales or slices the loose hay stacks. This tractor-powered equipment adds cost to the hay system but facilitates consumption control and reduces wastage to a minimum. In addition, a larger number of cattle can feed from one package because the bale or stack is distributed in a pasture or bunk. Daily feeding is also accomplished by allowing cattle in a feeding area with big packages for short periods of time, normally 30 minutes to one hour per day.

Controlled feeding with panels combines the advantages of reducing feeding labor and minimizing hay wastage. The big hay packages are fed as a unit, and panels prevent cattle from trampling the hay. Slant bar feeder panels are typically 5 feet high and 8, 10, 12, 14, or 16 feet long as required to surround the hay package. Four panels pinned at the corners allow the panels to fold from a square or rectangular shape into a diamond shape as the hay is consumed. The collapsible feature is essential for complete hay cleanup.

Feeding trials with large roll bales conducted at the Eastern Pasture Research Station located near Muskogee, Oklahoma, compared the three feeding methods described. Two types of hay, a common bermudagrass and a sorghum-sudan grass hybrid, were fed to bred heifers weighing between 650 and 700 pounds. The results of the feeding trial are expressed as a percentage of hay not consumed to hay fed and are tabulated in the table below.

HAY WASTED (%)

	Free Choice	Daily Feeding In Bunk	Controlled Feeding With Panels
Bermuda Grass	14.6	2.6	5.5
Sorghum-Sudan Grass	36.0	1.1	2.6

The feeding trials clearly illustrate the need for controlled feeding of big hay packages. Other tips that will reduce feeding wastage are:

1) Feed on a well-drained site to prevent the cattle and hay from standing in muddy conditions.

2) Do not feed more hay than can be consumed in one week. Hay exposed to the weather for more than one week will become less palatable.

3) Harvest high quality hay. Harvesting hay at the optimum conditions will result in more efficient feeding. Timely harvesting will provide a more nutritious and palatable hay. Also, proper storage is essential to assure high quality hay at feeding.

SILAGE

To evaluate the suitability of silage for a given farming enterprise, many factors must be considered. The first consideration is determining if the annual volume of silage utilized would be sufficient to justify the initial investment. Since silos have an expected lifetime between 10 and 20 years (depending on type of silo and severity of use), a long-term commitment to silage is essential to recover the investment. To achieve maximum efficiency during feeding, the livestock need to be centrally located near the silo. Trucks can be used to deliver silage to livestock grazing on winter pasture; however, long-distance hauling will become expensive because of the high moisture content. Automatic silage feeding is feasible only with the livestock confined to holding areas adjoining the silo. Another factor to evaluate is the economic and agronomic capability of the soil to produce silage crops. Finally, the silage system should be compared with other forage handling systems that satisfy the requirements for the livestock enterprise.

The equipment for a silage system is selected to match the type of silo, crop species, annual acreage, and so forth. Consequently, a typical silage system does not exist. However, to provide a comparison between hay and silage systems, assume a typical complement of field equipment is a medium duty PTO forage harvester with tractor towed forage wagons to transport the chopped forage to storage. Upright silos require a forage blower and horizontal silos need a tractor to pack the chopped forage. A windrower is also used if the harvested crop is wilted and stored as haylage in a gas-tight silo.

A cost comparison of silage systems and the traditional baling system is presented in the following table. Since the type of silo has a marked influence on the breakeven tonnage, each silage system is described as a function of the storage structure. These breakeven tonnages are valid only if the silo is filled once per year. Costs for individual machine operations and silos are listed in Tables III and IV, respectively.

BREAKEVEN ANNUAL TONNAGE FOR SILAGE SYSTEMS
COMPARED TO THE TRADITIONAL BALED HAY SYSTEM

Type of Silo	Tons	
	Silage	(Hay)
Horizontal Earthen Pit	350	(140)
Horizontal Concrete Lined Pit	400	(160)
Upright Concrete Stave	600	(240)
Upright Gas-Tight	1600*	(1000)

*Based on haylage (50 percent moisture)

The additional costs for a windrower and a gas-tight storage structure, both needed for haylage, raises the breakeven annual tonnage dramatically. However, two annual fillings of the gas-tight silo reduces the breakeven annual tonnage to approximately 800 tons of haylage or equivalently 500 tons of baled hay.

Of course, the selection of a silage system should not be based entirely on apparent economic advantages. The previous cost analysis for each of the systems did not account for the losses in storage. Losses in storage are dependent on the type of crop, crop maturity, management during filling and the type of storage structure. Cooperative USDA and state universities research has estimated farm silage losses for different types of silos. These losses were estimated under good management. The results were as follows:

Type of Silo	Percent of Loss	
	Average	Range
Horizontal Silos	15	10-25
Upright Concrete Stave	6	2-12
Upright Gas-Tight	5	1-11

Another factor to consider when selecting a silage system is the labor requirement for harvesting, handling, and feeding the silage. Total labor required to harvest, store, and feed forage as silage can be considerably less than for the traditional baled hay system. Typical labor requirements for silage from the field to feeding is 0.25 man-hours per ton or equivalently 0.63 man-hours per ton of forage at 20 percent moisture content. Labor requirements for a haylage operation are commonly 0.62 man-hours per ton or equivalently 0.99 man-hours per ton of forage at 20 percent moisture content. However, even with a reduced total labor requirement to harvest, store, and feed silage, normally three men are needed simultaneously during harvest. This peak labor requirement frequently eliminates the use of silage on family operated dairies.

SUMMARY

A variety of haying systems are available to either the commercial hay grower or the livestock operators that feed the hay produced. The primary objective of both types of hay growers is to increase profits and lower the labor requirements of harvesting and handling hay. The returns to land and management in producing, harvesting, and handling hay is not excessive; therefore, a haying system must be selected that contributes most to the overall operation. The system selected must have the capacity to minimize the losses due to timeliness without increasing the total costs above an acceptable level. However, before any haying system is selected, it must be determined that the managerial abilities and the system complement each other.

Commercial hay growers are facing large increases in costs due to the high labor requirements and increasing costs of hand hauling. The automatic bale wagon system can (1) provide opportunity for increased annual production, (2) lower handling costs from $1 to $3 per ton, and (3) reduce the risk of a weather damaged crop. The automatic bale wagon system has two major disadvantages: (1) A high annual tonnage is required to justify ownership. (2) The system requires a high level of management to achieve

the capacity that will minimize costs from individual machine components which comprise the total system. The bale wagon operator needs exceptional ability to achieve the maximum performance with the machine.

The use of loose hay stack wagons and roll balers producing 1200 pound bales is economically feasible for commercial hay growers only if the transportation distance to market is less than 50 miles. With continuing improvements in big package hay equipment, long distance transportation may soon be realistic. However, for cow-calf operators the availability of loose hay stack wagons and roll balers producing a large bale is an important breakthrough. The easiest way for these people to expand is with improved pastures and increased hay production on the land they currently own or farm. The traditional system of baling hay, with the high labor and cost limitations, has greatly discouraged such expansion. But loose hay stack wagon or large roll bale systems offer two primary advantages that would encourage expansion. First, they are basically a one-man operation or require only a limited amount of easy-to-manage hired labor. Second, significant cost reductions over traditional systems are feasible. Once the equipment is owned, the operator is more encouraged to put up lower quality, but readily acceptable forage such as straw, stover, etc., because the operating costs are so low. Cutting the traditional bale system costs in half with loose hay stack wagon or roll bale systems can be achieved.

While some of the new systems offer tremendous possibilities for the person who wants to enlarge his herd size, the low breakeven tonnage (about 100 tons per year for the 1 ton stack wagon or large roll baler) means that many operators who have had to rely on custom balers may now own equipment.

Even if ownership of one of the new systems may be justified on the basis of lower costs, there are some important disadvantages to be considered. Feeding losses with loose hay stacks or large roll bales may more than offset the theoretical cost advantage, particularly in areas of annual rainfall exceeding 35 inches per year. The problem is not primarily due to storage losses, but in the wastage as the hay is fed. Good management helps, particularly in providing feeding racks and forcing complete cleanup. Without feeding racks, controlled or limited feeding is essential to reduce feeding losses of loose hay stacks or large roll bales. To realize the maximum benefits from these big package systems, it is essential to select a storage and feeding system that minimizes hay wastage.

Some commercial alfalfa growers have used big package hay equipment with success. The systems are successful for a variety of reasons. Namely, markets are nearby and the labor and cost savings provide opportunities for increased returns to management. However, it should not be overlooked that proper management techniques are also employed. The low labor and cost savings encourage many producers to relax management and consequently harvest and store a lower quality hay. For highest quality hay, it is essential to harvest, store and feed hay utilizing the best management techniques available.

The recent and continuing development of new hay systems that save labor and cut costs is very encouraging for both the commercial hay grower and the dairyman that produces and harvests his own forage. Currently, the new systems provide the opportunity for management to select a system best suited for the particular operation. With the new systems available both increased production and profit can be realized by hay growers.

Silage is a low-labor forage system that can be completely mechanized from field to feeding. Consequently, silage systems are utilized on many dairies because of labor shortages and the potential for high quality forage at feeding. Since a silage system essentially replaces labor with a capital investment, high-level management is necessary to achieve maximum benefits and utilization from the system. Even though a larger capital investment is risky for many operations, a well-planned and properly managed silage system can providy good financial returns.

Table I

LIFE OF HAY EQUIPMENT IN OKLAHOMA

Machine	Reliable Life (Hours)	Obsolescence (Years)
Bale Handlers (Self-propelled)	800	8
Bale Mover (Roll)		
Mounted	800	8
Towed	800	8
Bale Wagon (Automatic)	800	8
Baler (Standard)	1000	8
Baler (Roll)	800	8
Forage Blower	1000	8
Forage Harvester (PTO)	1000	8
Forage Wagon	1000	8
Mower Conditioner	1000	8
Rake	1000	8
Stack Wagon (Loose Hay)	800	8
Stack Mover (Loose Hay)	800	8
Windrower	1000	8

Table II

COST OF OWNING AND OPERATING HAY EQUIPMENT*
(Total Cost Per Ton)

Machine	Size	New Cost	Tons Per Year 100	200	400	600	800	1000
Baler (Roll)	1200 lb	$ 5,500	$12.31	$6.73	$4.51	$3.77	$3.49	$3.35
Baler (Medium duty)	14"x18"	4,300	10.68	6.89	4.92	4.33	4.05	3.99
Baler (Heavy duty)	14"x18"	5,400	12.42	7.18	5.05	4.35	4.01	3.81
Bale Mover (Roll) - Economy Mover Tractor Mounted (2 moves)	1200 lb	200	6.04	5.93	5.86	5.84	5.84	5.84
Bale Mover (Roll) - Truck Towed	3 ton	6,000						
5 mile one-way haul			20.44	10.64	5.81	4.25	3.51	3.20
10 mile one-way haul			20.95	11.15	6.32	4.76	4.02	3.71
Bale Wagon (PTO) - Automatic	55 bales	6,100	12.53	7.35	4.42	3.75	3.56	3.42
Bale Wagon (PTO) - Automatic	104 bales	9,200	17.53	8.61	4.97	3.79	3.20	3.10
Bale Wagon (SP) - Automatic	160 bales	22,000	40.26	20.46	10.50	7.47	5.72	4.72
Mower Conditioner (PTO)	9½ ft	4,200	9.45	5.59	3.92	3.49	3.35	3.25
Rake - Single	9 ft	1,400	3.70	2.53	1.83	1.66	1.61	1.57
Rake - Tandem	18 ft	3,300	6.56	3.59	2.19	1.63	1.40	1.26
Stack Wagon	1 ton	7,000	14.15	8.20	4.84	4.07	3.86	3.69
Stack Wagon	3 ton	10,300	19.97	10.75	6.17	4.77	4.22	4.12
Stack Wagon	6 ton	16,600	31.34	15.60	8.90	6.66	5.82	5.38
Stack Mover (Wheeled)	1 ton	1,200	5.37	4.22	3.88	3.81	3.68	3.68
Stack Mover	3 ton	3,100	7.44	4.81	3.32	2.98	2.88	2.81
Stack Mover (Farm)	6 ton	4,800	9.74	5.42	3.38	2.67	2.23	2.03
Stack Mover (Highway)	6 ton	8,500						
5 mile one-way haul			24.07	12.27	6.44	4.48	3.55	3.02
10 mile one-way haul			24.44	12.64	6.81	4.85	3.92	3.39
25 mile one-way haul			25.20	13.40	7.57	5.61	4.68	4.15
Windrower (PTO)	12 ft	5,600	11.66	6.86	4.22	3.50	3.33	3.17
Windrower (SP)	14 ft	12,900	23.96	11.49	6.76	4.99	4.38	4.02

*All costs were calculated with the most recent cost data available at the time of writing this report.

Table III

COSTS FOR OWNING AND OPERATING SILAGE EQUIPMENT
(Total Cost Per Ton)

Machine	Size	New Cost	Tons @ 20%: / Tons @ 68%:	Tons Per Year 100 (250)	200 (500)	400 (1000)	600 (1500)	800 (2000)	1000 (2500)	1500 (3750)	2000 (5000)
Belt Feeder	125 ft	$ 2,800		$ 6.39	$ 3.73	$ 2.61	$ 2.46	$ 2.31	$ 2.26	$ 2.14	$ 2.14
Belt Feeder	250 ft	4,600		9.77	5.40	3.56	3.30	3.06	2.98	2.78	2.78
Chuck Wagon - Truck Mounted	5 ton	13,500		25.30	13.28	7.12	5.13	4.17	3.67	2.96	2.87
Forage Blower	65 inch	1,200		3.09	2.01	1.30	1.21	1.16	1.14	1.11	1.10
Forage Harvester (PTO) - Direct Cut	2 row	6,500		12.79	6.94	4.18	3.08	2.62	2.35	2.08	2.01
Forage Wagon	6 ton	3,900		7.36	3.85	2.20	1.54	1.26	1.10	0.94	0.89
Silage Loader (Front End Loader on Tractor)		2,500		5.59	3.17	2.18	1.86	1.70	1.61	1.55	1.50

			Tons @ 20%: / Tons @ 50%:	Tons Per Year 100 (160)	200 (320)	400 (640)	600 (960)	800 (1280)	1000 (1600)	1500 (2400)	2000 (3200)
Forage Blower	65 inch	$ 1,200		$ 3.40	$ 2.35	$ 1.80	$ 1.63	$ 1.55	$ 1.54	$ 1.50	$ 1.48
Forage Harvester (PTO) - Pickup		6,000		12.54	7.27	4.52	3.68	3.30	3.22	3.03	2.92
Forage Wagon	6 ton	3,900		7.57	4.14	2.36	1.81	1.56	1.51	1.39	1.32

All costs are based on a 20% moisture content forage to provide comparison with hay handling systems. Also, all costs were calculated with the most recent cost data available at the time of writing this report.

Table IV

STORAGE COSTS FOR HAY AND SILAGE
(Cost per Ton)

Type of Storage	Tons per Year					
	100	200	400	600	800	1000
Traditional Bales in Barn	$4.00	4.00	4.00	4.00	4.00	4.00
Silage in Horizontal * Earthen Pit (1 filling/yr)	$ .32	.32	.32	.32	.32	.32
Silage in Horizontal * Concrete Lined Pit (1 filling/yr)	$4.12	3.05	2.15	2.10	2.10	2.10
Silage in Upright Concrete Stave * (1 filling/yr)	$13.00	10.20	7.50	6.10	5.40	5.00
Haylage in Upright ** Gas-Tight (1 filling/yr)	$27.80	19.80	13.30	11.50	11.50	11.50
Haylage in Upright ** Gas-Tight (2 fillings/yr)	$18.40	13.90	9.90	7.75	6.65	5.75

* Moisture content is corrected from 68% to 20% for comparison with hay. To determine storage cost per ton of silage divide cost by 2.5

** Moisture content is corrected from 50% to 20% for comparison with hay. To determine storage cost per ton of haylage divide tabulated cost by 1.6

Life for each of the above storage structures was wassumed to be:

Hay Barn	20 Years
Horizontal Earthen Pit Silo	10 Years
Horizontal Concrete Lined Pit Silo	10 Years
Upright Concrete Stave Silo	15 Years
Upright Gas-Tight Silo	20 Years

Table V

CAPACITY AND LABOR REQUIREMENT FOR HAY EQUIPMENT IN OKLAHOMA

	Capacity* (Tons/Hr)	Labor Requirements (Man-Hrs/Ton)
Bale Handlers (SP - 3 men)	5.0	0.60
Bale Mover (Roll) - Tractor mounted		
Haul	2.5	0.40
Feed	3.0	0.33
Bale Mover (Roll) - Truck towed		
5 mile one-way haul	6.5	0.15
10 mile one-way haul	3.7	0.27
Bale Wagon (PTO - 55 bale) - Automatic	5.0	0.20
Bale Wagon (PTO - 104 bale) - Automatic	8.0	0.13
Bale Wagon (SP - 160 bale) - Automatic	13.7	0.07
Baler (Medium duty) - Standard	6.4	0.16
Baler (Heavy duty) - Standard	8.0	0.13
Baler (Roll)	7.5	0.13
Feed Bales (With pickup)	1.0	1.00
Hand Haul Bales (3 men)	2.7	1.11
Mower (7 ft)	2.9	0.34
Mower Conditioner (PTO - 9 1/4 ft)	4.1	0.24
Mower Conditioner (PTO - 12 ft)	4.9	0.20
Rake (Single - 9 ft)	5.2	0.19
Rake (Tandem - 18 ft)	10.0	0.10
Stack Wagon (Loose hay - 1 ton)	5.0	0.20
Stack Wagon (Loose hay - 3 ton)	6.5	0.15
Stack Wagon (Loose hay - 6 ton)	7.5	0.13
Stack Wagon (Loose hay - 8 ton)	8.5	0.12
Stack Mover (Loose hay - 1 ton)	2.5	0.40
Stack Mover (Loose hay - 3 ton)	5.0	0.20
Stack Mover (Loose hay - 6 ton) - Farm	10.0	0.10
Stack Mover (Loose hay - 8 ton) - Farm	15.0	0.07
Stack Mover (Loose hay - 6 ton) - Highway		
5 mile one-way haul	15.0	0.07
10 mile one-way haul	7.0	0.14
25 mile one-way haul	3.3	0.30
Windrower (SP - 14 ft)	5.7	0.18
Windrower (SP - 16 ft)	8.0	0.13

*Capacities are based on the assumption of overall average production of 1 ton per acre. On-farm hauling distances are assumed to be 1 mile.

Table VI

SILAGE EQUIPMENT CAPACITIES
AND LABOR REQUIREMENTS

	Capacity (Tons/Hr)	Labor Requirements*** (Man-Hrs/Ton)
Feed Silage (w/belt feeder)	3.0 (7.5)*	0.33
Feed Silage (w/chuckwagon) Truck mounted	6.0 (15.0)*	0.17
Feed Silage (w/mixer-feeder) Truck mounted	6.0 (15.0)*	0.17
Forage Blower	10.0 (25.0)*	0.10
Forage Harvester (PTO - direct cut)	10.0 (25.0)*	0.10
Forage Harvester (PTO - pickup)	6.3 (10.0)**	0.16
Forage Harvester (SP - direct cut)	18.0 (45.0)*	0.06
Forage Wagon	3.3 (8.3)*	0.30
Haul Silage (w/truck) 5 miles one-way	10.0 (25.0)*	0.10
Load Silage (front end loader)	6.0 (15.0)*	0.17
Upright Silo Unloader	3.0 (7.5)*	0.33

* Capacities in parentheses are based on silage at 68% moisture content. To provide comparison with hay equipment all labor requirements are converted to dry matter with 20% moisture.

** Capacities in parentheses are based on silage at 50% moisture content. To provide comparison with hay equipment all labor requirements are converted to dry matter with 20% moisture.

*** Capacities and labor requirements listed in Table I are averages based on observations made over a wide range of field conditions, operator skills and equipment conditions. The observations have also indicated that most capacities and labor requirements for individual operations are within 25% of those listed.