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CATTLE FEEDERS' INFORMATION

Published by Cooperating Universities and Livestock Feeders

L-1094

Texas A&M University

Agricultural Extension Service
John E. Hutchison, Director
College Station, Texas

Solid Waste Management for Cattle Feedlots

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Solid manure management involves the unit operations of collection, transportation, storage, processing and disposal or recycling. These operations encompass an array of techniques and equipment that can be used in various combinations. From these, feedlot operators should select manure management systems that minimize costs while satisfying environmental protection requirements.

COLLECTION AND TRANSPORTATION

Beef cattle excrete approximately 63 pounds of wet manure per day (85 percent moisture on wet weight basis; including feces and urine) per 1000 pounds liveweight. Natural processes of evaporation and biological decomposition reduce this to about a ton of solid manure (at 40 percent moisture) per animal per feeding period (150 days) that must be removed from the feedlot surface. Quantities to be removed deviate as much as 60 percent from this average figure depending upon ration, animal density, feedlot surfacing material, cleaning procedures and other factors.

Manure removal frequencies are dictated in part by climatic conditions, animal comfort, labor scheduling and water and air pollution potentials. Usually, however, solid wastes are collected from the feedlot surface after each pen of cattle has been shipped.

From an environmental protection standpoint, continuous aerobic decomposition of manure on the feedlot surface is desirable. Maintaining surface manure moisture contents in the range of 25 to 50 percent will aid in controlling dust and in promoting aerobic decomposition which is desirable for odor control. While the surface layer should be maintained in an aerobic state to minimize the formation and release of odorous gases, preserving an undisturbed anaerobic manure pack of several inches' thickness below the surface will reduce through denitrification any possibility of groundwater pollution by nitrates. To avoid odors during pen cleaning, only the surface manure layer should be removed.

Methods chosen for solid manure collection and transportation have a major impact on the overall economics of animal waste management. Capital and operating costs for solid manure handling systems vary with feedlot size, manure hauling distance and equipment use rate. For a 20,000 head feedlot with manure disposal areas located a mile away, systems that have been evaluated are ranked below in the order of least to highest operating cost:

1. Elevating scraper (self-propelled)
2. Commercial loader and spreader truck
3. Rotary scraper (tractor-towed)
4. Commercial loader and dump truck
5. Tractor loader and pull spreader
6. Tractor loader and dump truck

For all these systems, equipment size requirements and associated investment and operating costs decrease drastically as equipment usage is increased from 25 to 100 days per year; thereafter, costs vary little with equipment usage. Operating costs (dollars per animal per day) are lower for large feedlots than for small ones and also increase as the hauling distance is lengthened. Although their investment costs are competitive, the three systems involving a dump truck or a pull spreader have substantially higher operating costs than the other three systems. This is because of limited capacities and probably accounts for the unpopularity of these systems.

Of the other three handling systems (the most prevalent ones), the rotary scraper generally has the lowest *investment* cost. Investment costs are similar for both the elevating scraper and the combination of commercial loader and spreader truck.

For equipment use rates in excess of 50 days per year and feedlot capacities exceeding 10,000 head, the elevating scraper has the least *operating* cost for hauling distances of 1/4 to 3 miles. Where the manure haul distance is short (e.g. less than 1/2 mile), the rotary scraper is more economical to operate than the commercial loader (shown in figure 1) and spreader truck, and is cheaper than the elevating scraper for feedlots below 10,000 head in capacity and for use rates of 50 days per year or less. However, for manure haul distances exceeding about 1/2 mile, the commercial loader and spreader truck combination is cheaper to operate than the rotary scraper and, for distances above 3 miles, it is more economical than the elevating scraper (Table 1).

In specific situations, departures from these general trends may occur because of the inability to purchase and operate fractional units of equipment. Nevertheless, through proper equipment selection and frequent utilization, solid manure handling costs for open feedlots with adjacent cropland may be held below the operating cost value of $0.0035 per head per day, including depreciation and labor.

High transportation costs limit distances that manure can be hauled economically. Costs to feedyard managers and contractors for manure hauling and spreading vary widely, typically ranging from $1 to $1.75 per ton plus $0.05 per ton-mile.

STORAGE

Intermediate storage of manure in stockpiles allows regular removal of solids regardless of the immediate readiness of land for disposal. Mounding of solids inside the pens, an intermediate step in collection, promotes drainage and provides a dry resting area for cattle during adverse weather (figure 2). Further manure drying and decomposition accompanied by volume and weight reductions occur during storage. However, storage periods longer than 4 to 5 days without aeration will cause anaerobic conditions to develop, and malodors will be released upon excavation.

PROCESSING

Storage time can be utilized beneficially to compost manure in windrows (4 to 6 feet high) which are aerated by turning every 3 to 7 days or by injecting air using underlying perforated pipe. Windrow composting requires 15 to 21 days to complete if satisfactory moisture (40 to 60 percent) and temperature (130 to 170 degrees F) can be maintained. Aerobic composting produces no offensive odors; generates enough heat to kill weed seeds, fly larvae, and most pathogens; and reduces materials volume by 10 to 45 percent and weight by 30 to 60 percent. Loss of nitrogen through volatilization may lower the fertilizer value of finished compost. Composting requires careful management, and difficulties can be expected during prolonged periods of immoderate weather.

Table 1. Solid manure handling equipment with least operating cost

Manure hauling distance	Beef feedlot capacity: Less than 10,000 head	Beef feedlot capacity: Over 10,000 head
0 to 1/4 mile	Rotary scraper	Elevating scraper
1/4 to 3 miles	Elevating scraper	Elevating scraper
Over 3 miles	Commercial loader and spreader truck	Commercial loader and spreader truck

ULTIMATE DISPOSAL

The most satisfactory method of solid manure disposal is return to cropland. Of importance in crop production, manure contains nitrogen, phosphorus, and potassium and is an excellent source of micronutrients such as iron and zinc. It serves as a buffering agent in soils with high pH. Also, manure generally improves soil physical properties such as porosity, granulation, water infiltration rate and moisture retention capacity.

However, if not properly controlled, excessive manure applications can increase the potential for polluting surface or groundwater; can cause nitrogen concentrations in forage that pose a threat to animal health; and can cause salts such as sodium chloride to accumulate in concentrations that are toxic to plants and detrimental to soil structure. For conditions in the southern Great Plains, salt concentrations often are considered the limiting factor.

Salt accumulation can be controlled by regulating amounts and frequencies of manure and irrigation water applications and by limiting the salt intake of cattle on feed. Feedlot rations commonly contain 0.5 percent salt, but experiments in which sodium chloride content was varied from 0.0 percent to 1.0 percent gave no significant difference in average daily gain, feed intake, or carcass traits. As seen in figure 3, sodium concentrations in manure were closely related to sodium levels in the ration, ranging from 0.15 to 0.86 percent (or 30 to 170 pounds per acre for a 10-ton per acre manure application). Moderate applications of manure low in salts along with adequate leaching should not create soil salinity problems.

Recommended solid manure disposal rates for the Great Plains are dependent upon annual precipitation, irrigation applications, types of crops grown and soil characteristics. Manure application rates of 10 to 60 tons per acre per year (at 50 percent moisture content) have been used experimentally without impairment of crop yield, although long-term applications greater than 20 to

30 tons per acre per year need further study. Grain sorghum and corn forage yields on irrigated plots have been impaired by manure disposal rates exceeding about 100 tons per acre. Heavy applications are more detrimental to grain sorghum yields when manure is applied a few days, rather than several months, prior to preirrigation and planting. Some plant growth has been achieved on plots receiving as much as 900 tons of manure per acre. Presently, annual application rates in excess of 10 to 20 tons per acre cannot be recommended, but somewhat larger amounts can be successfully applied at intervals of 2 or more years.

Manure applied to cropland should be plowed under as soon as possible after spreading to retain nitrogen and reduce the possibility of surface water pollution, odors, fly emergence and pathogen survival.

The economic value of feedlot manure as fertilizer varies widely depending upon its composition, the price of commercial fertilizers and soil characteristics. Typical concentrations of elemental nitrogen, phosphorus and potassium in feedlot manure are given in Table 2. Assuming unit prices for nitrogen, phosphorus (P_2O_5) and potassium (K_2O) of 5, 10 and 5 cents per pound, respectively, feedlot manure at 40 percent moisture having average N-P-K concentrations (in oxide form) of 1.5 percent, 0.88 percent and 1.4 percent would be worth about $4.50 per ton (Table 2). However, many soils in the High Plains derive practically no benefit from phosphorus and potassium additions, so that the value of nitrogen alone may be only one-fourth to one-third of feedlot manure's full potential value. Furthermore, only about half the nitrogen applied as manure is available during the first cropping season. Hence, under the assumed conditions, the first-year fertilization value may be reduced further to 75 cents per ton, which may not offset handling costs. About half the residual nitrogen becomes available in each succeeding year, however, and indirect benefits derived from manure as a soil conditioner can outweigh its fertilization value, making manure handling attractive for many cropping situations.

The true value of manure can be measured as the value of increased yields resulting from its use minus application expenses. As an example of this, field tests of 3 years' duration in the Texas Panhandle demonstrated that peak yields and profits from corn silage can be obtained with manure applications of 10 and 20 tons per acre, individually or in combination with nitrogen at prescribed rates (100 to 180 pounds per acre). Fertilizer treatments generating lesser returns were nitrogen, nitrogen plus slurry mix (8-25-5), and no fertilizer.

Table 2. Analysis of solid feedlot manure

	— — — Percent — — —		
	N	P_2O_5	K_2O
Mean (dry weight)	2.5	1.5	2.3
High (dry weight)	3.5	2.0	3.3
Low (dry weight)	1.0	0.8	1.2
Mean (40 percent moisture)	1.5	0.9	1.4

Fig. 1. Commercial loader used to collect solid manure from the feedlot surface.

For fields receiving 10 tons per acre, net returns (considering application costs) from the first year's operation amounted to $9.50 increase in yield per ton of manure over yields realized from nitrogen fertilization only. When used with nitrogen fertilizer, manure applied at 10 tons per acre brought a net return of $9 per ton. The second year, manure used in combination with nitrogen boosted crop yields over nitrogen fertilized plots by $4.25 and $2.50 per ton for 10- and 20-ton per acre applications, respectively. In the third year, profits from 10- and 20-ton per acre manure applications (without additional fertilizer) were $8 and $4.25 per ton, respectively, above unfertilized plots, while 20 tons per acre of manure used with nitrogen returned only 50 cents per ton, partly resulting from moisture stress. After 3 years' application, soil tests on fields receiving feedlot manure at 10 to 20 tons per acre per year verified that salt buildup was not significant.

In other High Plains research, feedlot manure applied at annual rates of 10, 30, 60 and 120 tons per acre increased third-year grain sorghum yields over unfertilized plots by amounts equivalent to $6.20, $2, 90 cents and 40 cents per ton, respectively. Returns from the 10-ton per acre application clearly exceeded handling costs, estimated at $1.75 per ton.

Research into the long-range effects and benefits of manure on cropland is progressing at several locations in the Great Plains. Meanwhile, in many instances, an effective economic compromise between feedlots with a costly byproduct and farmers with a potential need for the material has apparently been reached.

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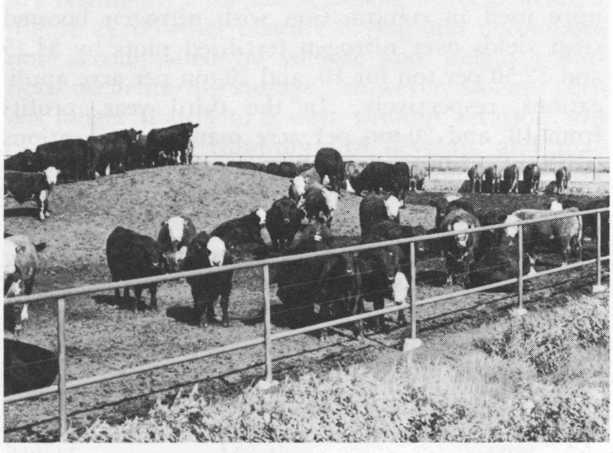

Fig. 2. Manure mounds inside feedpens reduce odors and enhance animal comfort through improved drainage.

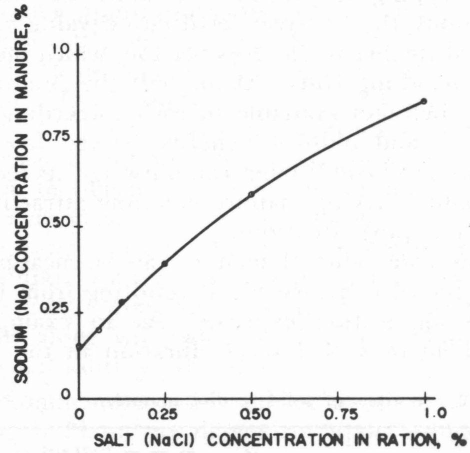

Fig. 3. Relationship between salt concentration in beef ration and in resulting manure.

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