Using cattle feedlot manure to control wind erosion

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ABSTRACT—The wind erosion control effectiveness of surface-applied and tilled-in cattle feedlot manure was compared with anchored wheat straw. Equations were developed to determine the amounts of manure and straw needed to provide wind erosion on different soil textures and conditions. A highly erodible sandy soil in Soil Conservation Service wind erodibility group 1 required 0.6, 14, or 23 tons per acre of anchored straw, surface-applied wet manure, or tilled-in wet manure, respectively, to keep erosion within the commonly accepted tolerance of 5 tons per acre. Curves were drawn for converting different amounts of surface-applied and tilled-in manure to their flat, small-grain wind erosion control equivalents. Overwinter weathering losses of surface-applied manure averaged 50 percent; tilled-in manure losses averaged 40 percent.

CONCENTRATING large numbers of cattle in feedlots has resulted in major manure disposal problems. Several studies (*4, 8, 9*) have been conducted to determine how manure applied to agricultural cropland affects crop production, groundwater pollution, and the physical and chemical properties of soil. In Nebraska up to 120 tons per acre of dry manure can be applied to a sorghum-sudan cross (*4*). In Texas, about 60 tons per acre of manure containing 50 percent water can be applied to hybrid grain sorghum [*Sorghum bicolor* (L.) Moench var. RS-671] without lowering crop yield (*8*).

The Canada Department of Agriculture Committee (*2*) suggested using manure on knolls and blowouts to stop soil drifting on cropland and rangeland but did not indicate the quantities of manure needed. King (*7*) also recommended using manure, without indicating application rates, to increase water-holding capacity and the resistance to wind erosion of sandy soils in Wisconsin.

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Woodruff and associates (*10*) suggested using 6 to 8 tons of manure on highly erosive knolls and blowouts (particularly in sandy soils) to prevent their spreading to other parts of the field. The recommendation was somewhat speculative, however, because it was based on assumptions about the function of manure in protecting soil and on calculations made using the wind-erosion equation (*11*).

Because we do not know the manure amounts needed to control wind erosion and because evidence indicates disposal efforts may result in manure being applied to entire fields, we need to obtain better information on the effectiveness of different amounts of manure and the minimum quantities needed to control wind erosion. Reported here are results of field research designed to determine the best ways to handle applied manure and the application rates needed to control wind erosion of sandy soils.

Methods and Procedure

Feedlot waste containing 66 percent water was obtained from Kansas State University beef-cattle research feedlots and applied to plots (12 by 36 feet) on a sandy soil (62 to 84 percent sand, 11 to 31 percent silt, and 4 to 8 percent clay) near Manhattan, Kansas. The manure, fresh from concrete-floored feedlots, contained no straw and only small amounts of fibrous material.

In the tests we used four rates—2, 5, 10, and 15 tons per acre (wet-weight)—of surface-applied manure and three rates—15, 30, and 60 tons per acre—of manure disked into the soil. The disk was a lightweight tandem with 16-in-diameter disks spaced 8 inches apart. It was operated to a depth of about 3 inches at a 20-degree angle. A control treatment and treatments of 0.5, 1, and 2 tons per acre of wheat straw anchored with a straight-disk packer also were included. All treatments were replicated three times, and a completely random statistical design was used.

Soil losses were based on portable wind-tunnel measurements made on September 28, 1972 (2 days after the manure was applied), and on May 17, 1973 (234 days after application). All tunnel tests were conducted at a free-stream windspeed of 36 miles per hour. Herbicides prevented weed growth prior to the May 17 tunnel tests, so the only cover at the time of the tests was the manure or straw. Data obtained, in addition to soil loss, weight of manure or straw, and water content of manure, included surface roughness (from pressure drop relationships in the tunnel), soil-particle size, soil cloddiness (clods > 0.84 mm in diameter), overwinter loss (weight) of manure, and precipitation.

Results and Discussion

Significance of Data

Analysis of variance of the soil loss data obtained soon after applying feedlot waste and after winter weathering showed a highly significant effect. Tables 1 and 2 present average soil losses for each treatment and statistical significances.

Because of the inherent experimental error associated with field wind-tunnel testing and because the plots varied somewhat in cloddiness and in the loose surface material available to blow, the data in table 1 are somewhat inconsistent. For example, 5 tons of surface-applied manure proved more effective than 10 tons. However, except for the 2-ton surface manure, all treatments significantly lowered soil loss 2 days after application, and the 30 and 60 tons of tilled manure, the 15 tons of surface-applied manure, and all straw treatments were significantly more effective than were the 2- and 10-ton surface-applied and

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15-ton tilled-manure treatments. The data indicate that at least 15 tons per acre of surface-applied manure and 30 tons per acre of tilled manure are required to reduce soil loss to less than a half ton per acre. This is an 88 percent reduction from no-treatment, and it approaches the 92 percent reduction attained with a half ton per acre of anchored straw.

Precipitation of 25.28 inches [11.67 inches is normal (*1*)] between September 28, 1972, and May 17, 1973, caused consolidation and crusting, leaving little loose sand and an extremely low wind erosion susceptibility at the time of the afterwinter-weathering tunnels tests. But data in table 2 show all treatments were significantly less erosive than the control, and the order of treatments (with few exceptions) was similar to the fall tests. The afterwinter data still showed that a half ton of straw and 15 tons of surface-applied manure reduced erosion about 90 percent but that 30 tons of tilled manure reduced erosion only 60 percent. The 2-ton manure rate was not included in the afterwinter tests because it did not differ from the control in the fall tests.

Table 1. Soil loss obtained from portable wind tunnel tests 2 days after applying manure.

Treatment[a]	*Soil Loss*[b] *(g)*
Control	151.7*[c]
2 tons SAM	124.7*†
15 tons TM	99.4†
10 tons SAM	90.5†
5 tons SAM	30.9‡
15 tons SAM	20.4‡
30 tons TM	16.9‡
0.5 ton S	12.3‡
1 ton S	8.5‡
60 tons TM	2.4‡
2 tons S	1.3‡

[a]SAM—manure applied to soil surface; TM—manure tandem disked into soil; S—wheat straw anchored with disk packer.
[b]Soil loss as measured in two Bagnold catchers, each sampling a ⅜-inch width of soil flow. Soil loss in grams × 0.026 = tons per acre.
[c]Means followed by same symbol or combination of same symbols do not differ statistically at the 5 percent level.

Table 2. Soil loss obtained from portable wind tunnel tests 234 days after applying manure.

Treatment[a]	*Soil Loss*[b] *(g)*
Control	3.36*[c]
10 tons SAM	1.59†
15 tons TM	1.49†‡
30 tons TM	1.35†‡§
5 tons SAM	0.80†‡§‖
1 ton S	0.33‡§‖
0.5 ton S	0.29‡§‖
15 tons SAM	0.22§‖
60 tons TM	0.19§‖
2 tons S	0.07‖

[a]SAM—manure applied to soil surface; TM—manure tandem disked into soil; S—wheat straw anchored with disk packer.
[b]Soil loss as measured in two Bagnold catchers, each sampling a ⅜-inch width of soil flow. Soil loss in grams × 0.026 = tons per acre.
[c]Means followed by same symbol or combination of same symbols do not differ statistically at the 5 percent level.

Cover and Wind Erodibility

We used multiple regression procedures to develop the following relationships between soil-loss data and data on manure or straw mulch rates and other variables. Because erodibility was extremely low at the time of afterweathering tunnel tests, we used only the data obtained from the fall tests, when erosion was significant.

Surface-applied manure (SAM):

$$\ln SL = 0.0862S - 0.0839C - 0.1362K - 5.0988 \quad R = 0.84$$

Tilled manure (TM):

$$\ln SL = 0.0919S - 0.0682C - 0.2335K - 4.9962 \quad R = 0.97$$

Anchored wheat straw:

$$\ln SL = 0.0794S - 1.1930C - 0.7757K - 3.5087 \quad R = 0.95$$

where SL is soil loss in tons per acre, C is manure or straw cover in tons per acre, K is soil surface roughness in inches, and S is sand content in percent.

Figure 1 shows soil loss versus amount of cover for each equation for a highly erodible soil having characteristics that would classify it in the Soil Conservation Service (SCS) wind erodibility group 1, i.e., 95 percent sand and roughness (K) associated with the amounts of cover indicated. The effectiveness of the two ways of handling applied manure differed, and the effectiveness of each method differed from that of applying anchored straw. For example, figure 1 shows that to hold soil loss to 5 tons per acre (the commonly accepted tolerance for maintaining soil productivity), about 0.6, 14, or 23 tons pers acre of anchored straw, surface-applied wet manure, or tilled-in wet manure, respectively, is required. In other words, the weight of manure needed for surface applications is about 23 times as much as that of straw. If the manure is to be tilled in, however, the weight of the material needed is about 38 times that required for anchored straw. Using manure for wind erosion control, therefore, does provide a way to dispose of substantial quantities of feedlot waste.

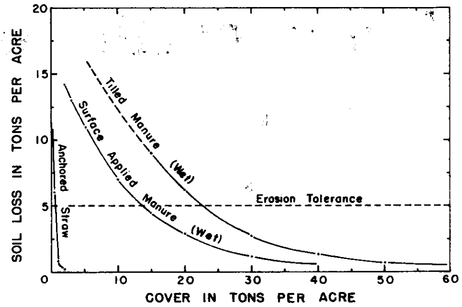

Figure 1. Soil loss versus cover as calculated by regression equations for a soil having 95 percent sand and roughness (K) associated with amount of cover.

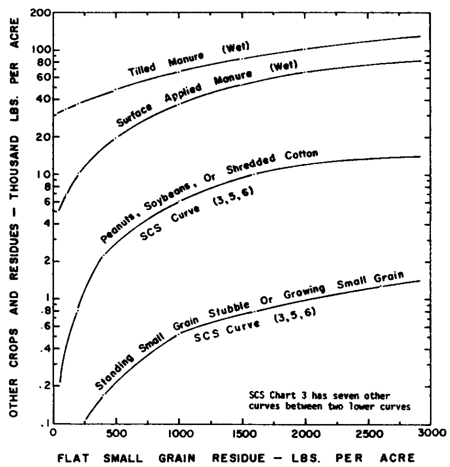

Figure 2. Chart for converting quantities of surface-applied and tilled-in wet manure to quantity of equivalent flat, small-grain residue. If dry manure weights are desired, multiply wet weights by 0.6.

Other factors, in addition to quantity of waste disposal, to consider in choosing between surface-applied and tilled-in methods of using manure for wind erosion control include effects on soil fertility and on environmental quality. Since much of the nitrogen in surface-applied manure will volatilize, it may be desirable to use greater amounts and till the manure into the soil. Also, surface runoff from fields where manure is applied on the surface may contain concentrations of pollutants that are too high, and again it may be desirable to incorporate greater amounts of manure into the soil.

In applying the wind erosion equation to design of wind erosion control practices, SCS, using a graph usually referred to as "Chart 3" (*3, 5, 6*), converts all residues and growing vegetation to equivalent amounts of flat, small-grain residue. Figure 2 presents —along with two curves from "Chart 3" (for reference)—curves for converting different amounts of surface-applied and tilled-in wet manure to their flat, small-grain equivalents. We derived the manure curves by comparing their effectiveness with that we obtained for anchored straw. The anchored straw, essentially flattened, appeared similar to the flatted field residues used in "Chart 3." Therefore, the manure-equivalent curves could be used in the wind erosion equation to design wind erosion control measures involving applications of feedlot wastes.

Overwinter Losses of Manure

Air-dried weights of manure determined in September and May (on and in the top 1½ inches of the soil) revealed an average 50 percent overwinter loss of surface-applied manure and a 40 percent loss of tilled-in manure. Thus, about 2.0 times more surface-applied manure and 1.7 times more tilled-in manure than needed to hold erosion to the tolerable level must be applied in the fall to obtain equal protection the following spring. This means that for the highly erodible soil used in figure 1 about 28 tons per acre (2.0 × 14) of surface-applied wet manure or 39 tons per acre (1.7 × 23) of tilled-in wet manure would need to be applied in the fall to meet the 5-ton-per-acre erosion tolerance the following spring.

In accepting this information, however, one must remember that our field plots were exposed to unusually high amounts of precipitation—more than twice that normal (for the time period of the tests) for the Manhattan, Kansas, area. Therefore, while biological decomposition was minimal in the sandy soil and cool temperatures, losses from the physical forces of rain and the resulting leaching, freezing, and thawing, and possibly some wind action, were substantial. Manure applied in areas having less precipitation than during this research likely would not sustain such large weathering losses. Perhaps a more reasonable loss would be about half that experienced in these tests.

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