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CROP YIELDS FROM LAND RECEIVING LARGE MANURE APPLICATIONS

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SUMMARY:
Up to 900 tons per acre of manure was applied to land using deep plowing techniques. Crops were grown and the yields are reported. Nitrate analyses of the forage produced are also reported and discussed.

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INTRODUCTION

Mass production of beef in large feedlots has had a vast impact upon many rural areas of Texas. During recent years, the beef cattle feeding industry has been a major economic force in the state. With the many benefits of large cattle feeding operations, one major problem continues to plague the industry, and that is its environmental effect on the community. Experience indicates that about 2 tons per year of a semi-composted manure accumulates for each head of feedlot capacity.

Most feedlot operators would like to see the manure utilized on land. However, they are finding it difficult to obtain sufficient land for utilizing all the manure produced by the feedlot. This has forced them to stockpile manure or to apply manure to land at rates larger than conventional applications.

Because of the salt content of beef manure, many researchers have reported decreased crop yields when large amounts of beef manure are applied to land. To assist the feedlot operator in finding a pragmatic solution to his manure utilization problem, a system of deep plowing large quantities of manure into the soil was investigated during 1970-1972.

To be an accepted practice, crop growth must be achieved within a growing season or two after applying a large amount of manure. The general premise of this research was that deep plowing would place the manure several inches below the soil surface and provide a manure-free surface soil for planting crops. After seeds germinate, the plant roots would grow into the buried manure and utilize the available nutrients.

This research has as its objectives to (1) evaluate the pollution of surface water, groundwater and soils and (2) evaluate crop growth yield and quality from plots receiving large manure applications. This paper will report only the effects on crop yields and crop quality of deep plowing beef manure. The primary crop quality parameter is the nitrate content of plant forage.

LITERATURE REVIEW

Deep plowing to alleviate specific soil problems has been studied numerous times. Hauser and Taylor (1964) evaluated deep plowing treatments on Pullman silty clay loam near Amarillo, Texas and obtained increased grain sorghum yields on the deep plowed plots. Mach, et al., (1967) investigated soil profile modification by backhoe mixing and deep plowing. Lyles, et al., (1963) reported the soil-mixing characteristics of three deep-tillage plows. Rasmussen, et al., (1964) indicated an improvement of slick spot soils in southwestern Idaho using deep tillage techniques. Burnett and Tackett (1968) showed that deep plowing Houston black clay improved root growth.

These investigators were primarily interested in deep tillage for greater crop production. Studies to evaluate deep plowing for disposal of wastes are virtually nil. Reed (1966) evaluated the Plow-Furrow-Cover method for disposal of poultry manure. Reddell, et al., (1971) evaluated four methods of deep plowing beef manure into the soil and found that up to 900 tons per acre of manure could be plowed under without creating a major surface water pollution source.

Numerous experiments in the United States and other countries during the past 100 years have been conducted on the fertilizer value of manure. However, due to the feed ration of most large feedlots, the beef manure from todays feedlot is chemically different than it was several years ago. Most of these earlier experiments were done at conventional application rates of approximately 10 tons per acre. During recent years, researchers in Texas, Nebraska, Kansas and Nevada have investigated the disposal of large amounts of beef manure from large feedlots on land.

Mathers and Stewart (1971) reported reduced grain sorghum yields on plots receiving more than 120 tons per acre of manure. They indicated a problem with soil salinity and nitrate pollution when excess manure was applied. Manges, et al., (1971) indicated decreased corn yields when manure is applied at rates greater than 103 tons of dry matter per acre. The long term effect of large manure applications deep plowed into the soil is still to be determined.

PROCEDURE

The experiments on deep plowing of beef manure were conducted at three locations: (a) El Paso, (b) Pecos and (c) Tulia, Texas. The El Paso and Pecos studies are on farms of the Texas Agricultural Experiment Station. The Tulia study is located at the Swisher County Cattle Company.

El Paso Studies

The farm at El Paso is in the Rio Grande River Valley about 20 miles south of El Paso. The average annual rainfall is about 7 in. per year and crop growth is achieved only through irrigation. Irrigation water from the Rio Grande River is of good quality and presents no severe salinity problems. However, when river water is not available, groundwater of poor quality is used and may have an adverse effect on crop growth if not properly managed.

The soil in the research plots at El Paso is a Vinton fine sandy loam with low moisture and fertility holding capacity. From 18 in. to 10 ft., the soil is very sandy. The water table fluctuates between 8 to 12 ft below land surface.

Pecos Studies

The farm at Pecos is located about 10 miles south of Pecos in an area extensively irrigated with groundwater. The topography is nearly level with an average slope of 0.4 percent. Pecos receives an average of 9 in. of rainfall per year.

The soil at Pecos is a Hoban silty clay loam. The A_p horizon texture ranges from clay loam to loam and is 8 to 18 in. thick. The A_c horizon has a texture of clay loam to silty clay loam 18 in. to 50 in. thick. Except for some isolated instances of perched groundwater, the water table at Pecos is deeper than 100 ft.

The groundwater used for irrigation at Pecos is of a poor quality, averaging approximately 2500 to 3000 ppm total dissolved solids. The soils themselves are on the saline side and very good management is required of farmers to achieve any type of crop growth. The land chosen for the manure disposal study at Pecos had not been very productive prior to this study because of the salinity problems. The addition of large amounts of manure to this already saline soil certainly did nothing to improve its crop growing ability.

Tulia Studies

The land at Tulia is located approximately 11 miles northeast of Tulia at a feedlot owned by the Swisher County Cattle Company. This area is in the heart of the Texas High Plains which is the center of the cattle feeding industry in Texas. The area is extensively irrigated with groundwater pumped from the Ogallala aquifer. The topography is flat and rainfall averages about 18 in. per year.

The soil at Tulia is a Pullman clay loam with excellent drainage characteristics. The soil is highly productive with excellent moisture and fertility holding capacity. The water table is at least 120 ft. deep. The groundwater is of excellent quality and poses none of the salinity hazards experienced at El Paso and Pecos.

Manure Applications

Manure for these studies was available from nearby feedlots. All three feedlots feed a high concentrate ration typical of commercial feedlots. Table 1 shows the moisture content and chemical analyses of the manure at all three sites. Wet manure application rates of 0, 300, 600 and 900 tons per acre were used at El Paso and Pecos, and rates of 0, 10, 25, 50, 100, 150, 300, 600 and 900 tons per acre were used at Tulia. Table 2 gives the wet and dry manure application rates and the application rates of the various chemical constituents in the manure. As can be seen, the 900 ton per acre treatment received in excess of 20,000 lbs per acre of N, P_2O_5, K_2O and N_aCl.

Tillage Equipment

The deep plowing equipment consisted of: (a) a 30-in. moldboard plowing 30 to 36 in. deep; (b) an 18-in. moldboard plowing 21 in. deep; (c) a trencher with a 27-in. digger wheel working 30 in. deep; (d) a 50-in. disc plowing 21-in. deep and (e) a 12-in. moldboard plowing 14 in. deep. Twelve plots at El Paso, 8 plots at Pecos and 9 plots at Tulia were installed in a split plot experimental design. The treatments are summarized as follows:

(A) El Paso-30-in. moldboard - 0, 300, 600 and 900 tons per acre;
(B) El Paso-18-in. moldboard - 0, 300, 600 and 900 tons per acre;
(C) El Paso-27-in. trencher - 0, 300, 600 and 900 tons per acres;

(D) Pecos - 30-in. moldboard - 0,300,600 and 900 tons per acres;
(E) Pecos - 50-in. disc - 0, 300, 600 and 900 tons per acre;
(F) Tulia - 30-in. moldboard - 0, 100, 300, 600 and 900 tons per acre; and
(G) Tulia - 12-in. moldboard - 10, 25 and 50 tons per acre.

An evaluation of the disposal of beef manure using the above described tillage equipment was made by Reddell, et al., (1971).

Cropping Treatments

El Paso--The plots at El Paso were installed during April and May of 1970. No attempt to plant a crop was made during the summer of 1970. However, the plots were irrigated and native weeds and grass were allowed to grow and were harvested.

During November of 1970, the plots were planted with barley, sweet clover and sugar beets. The sweet clover and sugar beets did not come up to a stand, even in the check plots where no manure was applied. However, the barley made excellent growth on all plots. During January of 1971, a severe cold spell for this part of Texas dropped temperatures to below zero for several days. This resulted in a freeze kill of the barley and thus no yields were ever obtained.

The plots were plowed and during May of 1971 corn, cotton and forage sorghum were planted. These crops were harvested during the fall of 1971 and the results are reported in this paper. The plots lay fallow during the winter of 1971-72. Corn and forage sorghum were planted in May of 1972 and harvested in August of 1972. These results are also reported in this paper.

Pecos--The plots at Pecos were installed during May and June of 1970 and no crops were planted during the summer of 1970. The plots were irrigated twice during the summer of 1970 to keep an adequate moisture content in the soil for decomposing the manure. The plots were plowed and kept free of weeds and grass.

During October of 1970, barley, alfalfa and sugar beets were planted. The alfalfa made good growth on all plots and good yields have been obtained. The barley also made excellent growth. However, the severe freeze during January of 1971 and a severe drought during the spring of 1971 prevented any kind of yield correlation.

Except for the alfalfa, the plots were plowed and cotton was planted during June of 1971. The cotton did not germinate adequately on any plots and several replantings were necessary to obtain an adequate stand. The cotton was harvested during November of 1971.

The plots were allowed to stand fallow during the winter of 1971-72. In May of 1972, grain sorghum and cotton were planted but insufficient germination took place on any of the plots including the check (no manure) plots. In June of 1972, the plots were replanted. A hail storm on the young plants plus severe salt damage prevented the crop from developing. Except for the alfalfa, no yield data are available for 1972 at Pecos.

Tulia--The plots at Tulia were not installed until August of 1971. This is a little over a year after the plots at El Paso and Pecos were installed. Seedbed preparation at Tulia was begun immediately after deep plowing the manure and wheat was planted in September of 1972. Excellent growth was obtained by the wheat on all plots. In January of 1972, clippings from all plots were made and the yields calculated. Cattle were turned onto the wheat pasture in February of 1972 and no additional clippings for wheat yields were obtained.

Corn was planted on the plots in May of 1972 and harvested in September of 1972. Grain sorghum was planted in June of 1972 and harvested in October of 1972. These yields for corn and grain sorghum are reported in this paper.

RESULTS AND DISCUSSION

The general premise of this research was that deep plowing manure into the soil would allow crops to be grown, even though tremendous amounts of salt are added to the soil system. No known previous work had examined the reaction of a soil when such large quantities of nutrients and salts were plowed into the soil system.

There is a substantial response to the manure application rate. During the summer of 1970 immediately after the manure application, the plots at El Paso were allowed to grow back with native grass and weeds. The forage was harvested in the fall of 1971 and the yields are shown in Table 3. The 600 and 900 ton per acre plots reduced yields significantly.

However, crops planted and grown during 1971 and 1972 show a different response. As shown in Figs. 1 and 2, good yields were obtained from corn and forage sorghum grown on these plots. A significant difference at the 95 percent level existed between the mean yield from the 300 ton per acre plot and the yields from the 0, 600 and 900 ton per acre plots. This difference was substantial with the 300 ton per acre plot yielding about 62 percent more forage than the check plot (0 tons/acre) in 1971. While yields from the 600 and 900 ton per acre plots were less than those from the 300 ton per acre plot, they were larger than yields from the check plot.

There was a significant difference in forage yields from the two crops, with the forage sorghum producing more forage than the corn. Also, the forage sorghum produced significantly more forage in 1972 than in 1971. However, the corn produced significantly less forage in 1972 than in 1971. This is believed to be the result of planting a different variety of corn in 1972.

A comparison of mean yields from the three tillage treatments used at El Paso is shown in Table 4. Although, there appears to be a tendency for the trencher treatment to produce more forage, the difference is not significantly different at the 95 percent level for either 1971 or 1972.

The nitrate content of forage from the 300, 600 and 900 ton per acre treatments was significantly greater than from the check plot as shown in Table 5. The nitrate content of the corn increased 5 fold from approximately 0.1 percent to 0.5 percent, and was about the same value for both 1971 and 1972.

The forage sorghum had a nitrate content in 1971 that ranged from 0.1 percent for the check plot to 1.1 percent for the 900 ton per acre plots. This is significantly greater than the nitrate content of the corn. However, during

Table 3. Dry matter yield of grass and weeds on manure plots at El Paso during summer of 1970.

Manure Application (tons/acre)	Dry Matter Yield (lbs/acre)
0	5464
300	4032
600	815
900	555

Table 4. Average dry matter yields of corn and forage sorghum on plots with different tillage treatments at El Paso during 1971 and 1972.

Tillage Treatment	1971 Dry Matter Yield of corn and forage sorghum (lbs/acre)	1972 Dry Matter Yield of corn and forage sorghum (lbs/acre)
30-in Moldboard	5301	6294
18-in Moldboard	6399	6234
Trencher	6721	6494

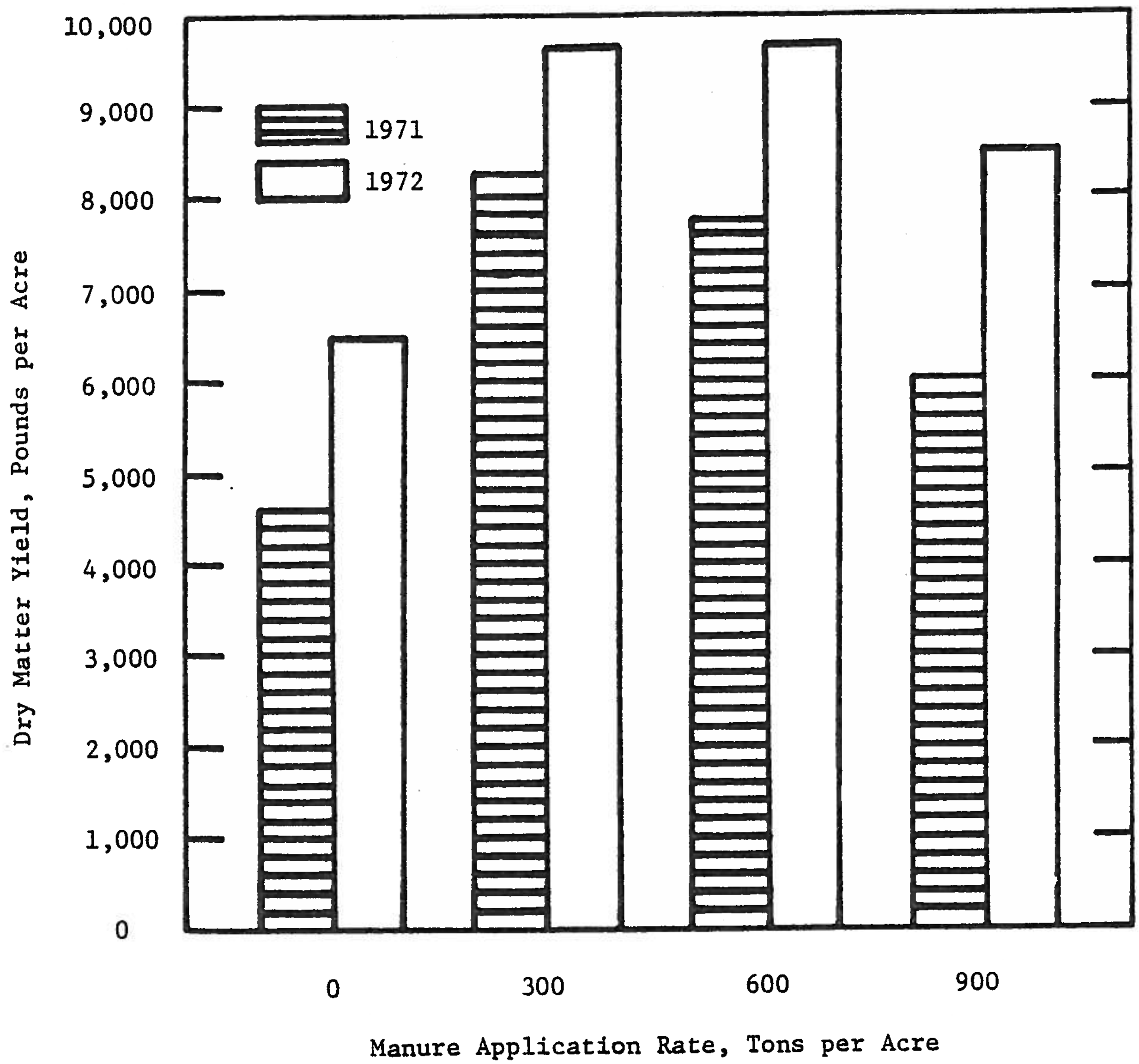

FIGURE 1. Forage yield of forage sorghum at El Paso on deep plowed manure plots.

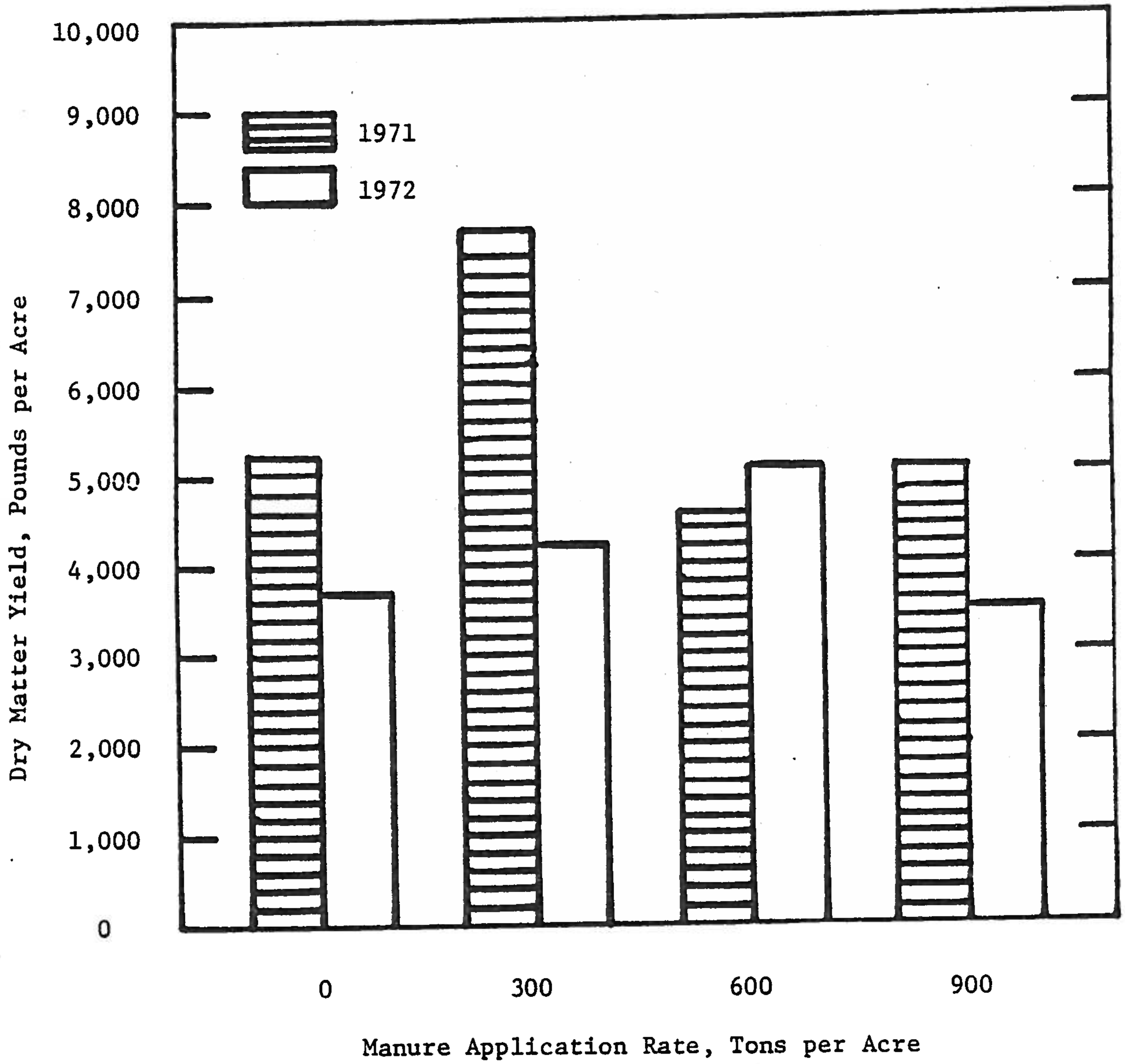

FIGURE 2. Forage yield of corn at El Paso on deep plowed manure plots.

Table 5. Nitrate content of corn and forage sorghum grown at El Paso during 1971 and 1972.

Manure Application (tons/acre)	Forage Sorghum NO_3 percent of dry weight		Corn NO_3 percent of dry weight	
	1971	1972	1971	1972
0	0.08	0.04	0.09	0.06
300	0.53	0.16	0.52	0.49
600	0.83	0.36	0.45	0.50
900	1.06	0.38	0.52	0.37

Table 6. Chemical content of corn and forage sorghum grown at El Paso during 1972.

Manure Application (tons/acre)	Chemical Content, percent of dry weight					
	Forage Sorghum			Corn		
	N	P_2O_5	K_2O	N	P_2O_5	K_2O
0	0.77	0.37	1.58	1.10	0.34	1.92
300	1.32	0.50	1.58	1.53	0.57	2.38
600	1.44	0.84	1.87	1.60	0.56	2.19
900	1.45	0.74	1.73	1.46	0.61	2.21

1972, the nitrate content of the forage sorghum was significantly reduced and did not exceed 0.4 percent. It is believed that forage with nitrate contents of less than 0.5 percent can be fed to livestock under proper management without causing health hazards. Nitrate values in the range of one percent will probably pose some problems. Considerable controversy exists on a safe value for nitrates in forage.

The chemical content of the corn and forage sorghum grown at El Paso in 1972 is shown in Table 6. Again, there is a significant difference between the check plot and the 300, 600 and 900 ton per acre plots. Total nitrogen ranged from 0.8 percent to 1.5 percent while P_2O_5 ranged from 0.4 percent to 0.8 percent and K_2O ranged from 1.6 percent to 2.4 percent.

The yield of wheat, corn and grain sorghum at the Tulia research site is shown in Table 7. The wheat was planted immediately after plowing the manure under and no significant effect on wheat yields from the heavy manure applications is noticeable. It is perhaps significant to point out that the 10, 25 and 50 ton per acre plots at Tulia were not deep plowed. This is perhaps the reason for the low wheat yields on the 25 and 50 ton per acre plots.

The corn yields in Table 7 indicate maximum production on the 10 ton per acre plot. The yields for the 0, 25, 50, 100 and 150 ton per acre plots are not significantly different. However, a reduction in yield occurs on the 300, 600 and 900 ton per acre plots. The yield on the 900 ton per acre plot is only about one-third of the peak yield on the 10 ton per acre plot.

Grain yields on the grain sorghum indicate a trend similar to that produced by the corn. The one main difference appears to be that grain yields increased slightly from the check plot to the 150 ton per acre plot. A reduction in yield then occurs on the 300, 600 and 900 ton per acre plots. Again the yield on the 900 ton per acre plot was only about one-third of the peak yield which occurred on the 150 ton per acre plot.

The nitrate content of the wheat forage and corn forage at Tulia are also shown in Table 7. In contrast with the results at El Paso, the nitrate content of the wheat and corn at Tulia does not increase with the larger manure applications. In fact, the highest nitrate contents in the forage at Tulia are from the 10, 25 and 50 ton per acre plots. There appears to be little reason for not feeding the forage at Tulia to livestock. In fact, the feedlot did use the corn for ensilage.

The difference between the nitrate content of forage samples from Tulia and El Paso is believed to be mainly a difference in soil types. The soil at El Paso is sandy and well aerated. The soil at Tulia is a clay loam and is not as well aerated. This difference could affect the decomposition rate of the manure in the soil. Other factors, such as moisture stress, sunlight and temperature, could also create a difference.

In addition to the yields described above for forage crops at El Paso and Tulia, cotton on plots receiving 0, 300, 600 and 900 tons per acre of manure at Pecos yielded 1.9, 3.3, 3.5 and 3.0 bales per acre respectively in 1971. These would be considered very good cotton yields for the Pecos area. Although not reported here, alfalfa and barley on plots receiving large manure applications at Pecos have grown very well. However, considerable difficulty has been

Table 7. Yields and nitrate content of crops produced from the Tulia plots during 1972.

Manure Application Rate (tons/acre)	Wheat: Dry Matter Yield Sept. 1971 to Jan. 1972 (lbs/acre)	Wheat: Nitrate Content (percent of dry weight)	Corn: Dry Matter Yield (lbs/acre)	Corn: Nitrate Content (percent of dry weight)	Grain Sorghum: Grain Yield Corrected to moisture content of 15 percent (lbs/acre)	Grain Sorghum: Nitrate Content (percent of dry weight)
0	1050	0.24	12,490	0.22	2720	-
10	1020	0.25	15,172	0.38	4060	-
25	730	0.25	13,406	0.34	5440	-
50	580	0.27	13,162	0.56	5660	-
100	920	0.18	10,318	0.27	5540	-
150	880	0.18	12,689	0.29	6030	-
300	1100	0.12	9,710	0.21	5650	-
600	1200	0.21	6,018	0.19	4125	-
900	990	0.20	5,197	0.31	2095	-

encountered when growing grain sorghum and forage sorghum at the Pecos location. This is a result of the severe salinity problem in the area complicated by the addition of the manure.

SUMMARY AND CONCLUSIONS

An investigation of deep plowing up to 900 tons per acre of beef manure into the soil was conducted at three locations in Texas: (a) El Paso, (b) Pecos and (c) Tulia. The manure was plowed under up to 36 in. deep using large tillage equipment. Corn and forage sorghum at El Paso indicate a peak yield on plots receiving 300 tons per acre of manure. However, yields on plots receiving 900 tons per acre exceeded the yields of the check plot (0 tons per acre).

Corn and grain sorghum yields were considered excellent for all plots at Tulia receiving up to 300 tons of manure per acre. The 600 and 900 ton per acre treatments reduced yields of both corn and grain sorghum. The 900 ton per acre plot reduced yields to approximately one-third of the peak yield.

Nitrate content of the forage samples at El Paso and Tulia were very different. Nitrate contents at Tulia were less than 0.4 percent and the higher values occurred on the 10, 25 and 50 ton per acre plots. However, the nitrate content of forage at El Paso was much higher and exceeded one percent nitrate in one instance in 1971. Special management would be required to feed this forage to livestock. However, the 1972 nitrate content of all forage at El Paso was less than 0.4 percent and is believed to be safe for feeding.

This work indicates that crops can be grown on land receiving up to 900 tons per acre of manure. Diminished yields may result the first year, but the yields will increase the second and third years after the manure application.

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