EXECUTIVE SUMMARY

Project Title: **Irrigation Runoff Water Quality Impacts and Economics of High-load Single-frequency (HLSF) Applications of Feedlot Manure - An Update**

Research Objective: To evaluate water quality impacts and the economic consequences of utilizing HLSF applications of feedlot manure in lieu of annual applications of inorganic fertilizers on irrigated crop rotations.

This experiment was designed to assess irrigation runoff water quality impacts of manure vs. inorganic fertilizer and not to retest sources of fertilizer. No attempt was made to measure deeply percolated nutrients below the root zone other than nitrates, and then only to the 8 ft. depth.

Crop Rotation: 1991 fully irrigated corn and 1992 double-cropped wheat.

Research Results: Water Quality, Yields and Economics

- Low nitrate (NO_3-N) runoff levels were observed for 11 irrigations during 91-92.
- Low and acceptable salinity levels were measured though a 2-yr, 2-crop sequence. Increased levels were observed at the end of study.
- Enhanced water intake of 8 to 24% with the HLSF manure application.
- 1991 corn yields were the same using HLSF manure and inorganic fertilization.
- 1992 Wheat yields were higher with inorganic fertilizer but were likely due to a higher N level than available from manure.
- Using HLSF manure, profits were $4/ac higher than inorganic fertilizer.
- The crop sequence appears to utilize most nutrients made available by HLSF manure allowing subsequent use of irrigation runoff water.
- Preliminary evidence exists of percolated nitrate concentrations below the root zone (4 ft.) for both fertilizer sources.

Irrigation Runoff Water Quality Impacts and Economics of High-load Single-frequency (HLSF) Applications of Feedlot Manure - An Update

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SUMMARY

Water quality of runoff from 11 surface irrigations on both corn and double-cropped wheat was generally not significantly different when comparing a HLSF manure application of 21 tons/ac to high rates of inorganic fertilizers, N and P. Measured levels of nitrate (NO_3-N), salinity (EC), phosphorus (PO_4) and chlorides were low. EC levels were increasing following the wheat sequence, but still considered acceptable. All irrigation runoff water quality is considered acceptable for many livestock and irrigation purposes.

HLSF manure increased water intake for 5 of 12 irrigations during the 2 crop evaluation period. Intake depths of each respective irrigation were generally different as expected.

A preliminary economic analysis of HLSF manure versus high-rate inorganic fertilizers indicates a slight profit advantage for HLSF manure, assuming a purchase, cost of $3 per ton delivered and applied.

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INTRODUCTION

Livestock and poultry confinement feeding in the U.S. has led to waste disposal and environmental concerns as well as state and federal water and air pollution abatement regulations (Sweeten, 1991). Concerns have been reflected in an outpouring of research and technical information and in passage of the 1972 Federal Water Pollution Control Act Amendments. The latter development led to enactment by EPA of effluent guidelines and new source performance standards in 1974 for the "feedlot" point source category (which included all livestock and poultry species). Sources of surface and groundwater contamination include confinement feeding floors and open feedlots; manure treatment and storage lagoons or ponds; manure stockpiles; fields used for manure land application; accumulations around livestock watering locations; and infrequently used pens, spray equipment, dipping vats, disposal sites for pesticide and rinsate, and/or chemical containers (Sweeten, 1992).

The semi-arid Texas High Plains region includes about 4 million intensively irrigated, highly fertilized cropland acres (Texas Water Development Board, 1989). Over 80 feedlots, with annual capacities exceeding 5,000 head, feed 4.5 to 5 million head of cattle yearly. Additional cattle are fed in bordering areas of New Mexico and Oklahoma (Northern et al., 1992). At one tone per head, this results in 4.5 to 5 million tons per year availability of feedlot manure in the area (Stewart 1972). Most of this manure is used as cropland fertilizer (Sweeten and Withers, 1990), but in some cases accumulates in stockpiles at the feedlots.

Over time, nitrogen (N) available from high-load single-frequency (HLSF) feedlot manure applications to cropland can approach the diminishing N requirements of 2-, 3-, or 4-crop rotations (adapted from Mathers et al., 1975). Crop sequences can be planned to use manure-N as it nitrifies over time.

Feedlot manure provides other benefits such as increased soil aggregate stability, increased water-holding capacity, and a higher infiltration rate (Elson 1941; Unger and Stewart 1974; Mathers and Stewart 1980; Mathers et al. 1977). These advantages are especially significant in areas where soils are high in clay content or low in organic matter.

In the '60s, water quality investigations by USDA scientists at Bushland, TX., found no surface (furrow) irrigation runoff concentrations of nitrates, phosphates, or chlorides following large feedlot waste applications. The manure was incorporated to moderately deep soil depths by moldboarding, a more common tillage practice in the past than presently (Mathers et al. 1977). A limitation, however, of using extremely high HLSF manure rates is the potential of soil salt concentrations. Mathers and Stewart (1983) reported sorghum yields were reduced due to high salt buildup immediately after a single application of 120 tons/ac or more. The buildup of salt and crop yield reduction was also evident with yearly applications of 30 tons/ac.

Unlike the past deep moldboarding techniques used in the USDA research of the '60s, farmers today in much of the Texas High Plains typically incorporate manure by disk tillage. Then, chiseling or deep ripping is used to enhance irrigation water intake, especially on fine-textured, slowly permeable soils. (Moldboard plowing remains a common practice on coarse-textured sandy soils wherein the primary objective is to reduce wind erosion of bare soil, not necessarily to increase water intake and soil water storage). A more complete review of manure research and the environmental, agronomic, and economic implications can be found in Bonner and Harman, 1992.

Research Objective: **To evaluate water quality impacts and the economic consequences of utilizing HLSF applications of feedlot manure in lieu of annual applications of inorganic fertilizers on irrigated crop rotations.**

The economic advantages of HLSF manure applications using compatible cropping sequences with the dynamic nitrification process are derived initially from the potential of minimizing tillage costs of the 2nd, 3rd, and subsequent crops of the rotation, and secondly, from the reduced need of repeatedly applying and incorporating commercial fertilizers for each crop. Of course, the initial cost of nutrients is locked-in which may be either an advantage or disadvantage, depending on subsequent fertilizer prices. A disadvantage may be the accumulation of salt or other mineral element loadings, although salinity is of most concern. The economic payoff of manure however depends not so much on the value of all contained nutrients, but rather on the purchase price of supplemental nutrients needed for adequate crop production.

RESEARCH METHODS

This experiment was designed to assess runoff water quality impacts of manure vs. inorganic fertilizer and not to retest sources of fertilizer regarding comparative yields or sources of N and P except as they relate to the 2nd crop, wheat, and the subsequent yield impacts.

The research was conducted during 1991 and 1992 on a Sherm silty clay loam at the North Plains Research Field, Etter, TX. A near 21-ton/ac HLSF application of feedlot manure in 1991, the first year of a 2-year corn/wheat rotation, was compared with yearly inorganic fertilizer applications. To assist in approximating the high nutrient impacts of manure on irrigation runoff water quality, applications of inorganic N and phosphorous (P) were larger than usually recommended, and in the case of N, the rate was somewhat higher than the estimated but variable 2-year availability of manure-N. Manure analysis indicated a dry matter content of 2.09% total N, 0.72% P, and 35% water.

Corn: After analyzing the nutrient contents of feedlot manure and determining the initial status of field-site fertility, bulk density, organic matter, and the soil intake rate, feedlot manure was applied preplant at about 21 tons/ac. Inorganic N (anhydrous ammonia) was applied at 150#/ac preplant and 242#/ac sidedress. All of the 300#/ac P (triple superphosphate) was applied preplant, and also incorporated by disk tillage near the same time manure was incorporated. Manure was incorporated twice by offset disk and the triple superphosphate once.

Afterwards, all treatments were deep ripped; tandem disked twice; 30-inch beds were formed; short-residual herbicides were applied; and all plots were preirrigated in March. Up to 7 seasonal irrigations for corn were planned, with the actual number being 6 as dictated by rainfall events and irrigation water availability.

Wheat: Prior to seeding double-cropped wheat, 180#/ac N was applied but no inorganic P was applied; nor was more manure applied to the manure wheat treatment. Because mineralized N is released at varying rates and amounts over time as the winter wheat growing season advances, the latter part of the cropping sequence was not designed to be equally balanced between fertilizer sources regarding N and P availability for the 2nd crop.

After shredding corn stalks, wheat beds were reformed with a disk bedder. Wheat was seeded prior to applying the emergence irrigation. Four irrigations were applied in the spring of 1992 at joint, boot, head, and dough physiological stages of growth. No water quality cinolyses were made of the joint irrigation due to sampling equipment failure.

Data acquisition and analyses: Irrigation runoff water quality, runoff and intake rates were of special interest. Differences in EC (a proxy for salts), NO_3-N, and plant available P were assessed.

Yields, fertilizer requirements, irrigation levels, and requirements of tillage and herbicides were monitored to develop input/output budgets for the corn/wheat rotation and each fertilizer treatment. For the affected inputs and crops, changes in costs of production, gross income, and profits were computed.

TENTATIVE WATER QUALITY AND YIELD RESULTS

While only one 2-year crop rotation has been assessed, the tentative environmental, agronomic, and economic impacts of the 1991 corn experiment and the 1992 impacts of irrigating wheat generally revealed that using an actual 21-ton/ac HLSF manure application did not significantly degrade irrigation runoff water for crop irrigation purposes. Salt concentration in preplant irrigation runoff water using manure, as determined from electrical conductance

(EC), was double that of runoff water using inorganic fertilizer; 642 μmhos/cm for manure versus 305 μmhos/cm for inorganic N and P, Figure 1, while later levels fell to 100-300 μmhos. Later in the wheat crop, both levels of EC increased. Tillage, prior to wheat seeding, apparently caused both sources of fertilizer to increase EC levels. While the final values were declining, further monitoring may be necessary due to the increasing trend. Also, in Figure 1, NO_3-N concentrations in runoff during 10 seasonal irrigations after the manure application were mostly similar and low compared with the runoff of the inorganic treatment; ranging from less than 0.5 to about 2.5 mg/L. Higher but still acceptable levels of 6 and 7.4 mg/L occurred during runoff of the first corn preplant irrigation for inorganic and manure, respectively. As nitrification occurred between the time of corn harvest and wheat emergence, an increased level of NO_3-N was available until the end of the wheat growth (Fig. 1). Total P concentrations (not graphed) were essentially constant and also low.

The comparative corn yields in 1991 were statistically the same--203 vs. 196 bu/acre for the inorganic and manure treatments, respectively. The wheat yields were significantly higher (approx. 91 in/ac after the addition of 180# N- versus 72 bu/ac) for the inorganic than for the HLSF manure.

Applying 21 tons/ac manure in a single application increased irrigation intake 8% in 1991. When field soil conditions were dry before preplant irrigation in 1991 and when the soil was drying down after mid-season, water infiltration increased on plots receiving manure 8% to 24%. In 1992, HLSF manure increased intake per irrigation event from 13% to over double than of the inorganic treatments. The doubling event occurred during a low intake event however. The average increase was over 16%.

The few cautions thus far of using HLSF manure applications are: (1) Highly variable spot applications of 16.5 to 27.5 tons/ac manure caused isolated high salt concentrations resulting in leaf scald, retardance, and/or killing of corn seedlings, (2) and EC needs to be monitored in time with subsequent rotations to monitor salinity buildup.

ECONOMIC RESULTS

The economic results are summarized in Table 1. Corn sales are the same for each type of fertilizer since there was no significant difference in yields of 196 bu/ac for manure and 203 bu/ac for inorganic fertilizers. However, 1992 double-cropped inorganic wheat yields after corn were significantly higher -- 90.8 bu/ac -- after 180# N/ac was added than 71.7 bu/ac using no more manure. As a result, wheat sales were increased $76/ac. Even so, the corn/wheat crop sequence profits over specified cost changes were $4/ac higher using HLSF manure.

Excess values of N and P in the root zone included over $4/ac excess nitrate-N residual value for the inorganic treatment. Nearly $76/ac excess residual value of P remained after using manure than the inorganic treatment. Soils having deficits of these nutrients could be benefitted economically. Other substantial nutrient residuals in the root zone differed with manure leaving more S and zinc (Zn); two other occasionally applied nutrients to area corn.

It is not possible to appraise the discounted or real value (in contrast to the nominal value) of these residual nutrients since neither specific farm soil deficiencies, the subsequent crop nutrient requirements, nor the time of uptake is known. Producers familiar with their soils, the fertility status, and crops to be produced can make an informed decision regarding the value of these excess soil nutrients. This analysis, however, indicates that manure costing $3/ton can be competitive by using infrequent, single, high rates compared with near-equal applied levels of inorganic N and P.

LIMITATIONS

These results, after only one 2-crop sequence, should be considered tentative regarding the adequacy of a HLSF application of 21 tons/ac manure in providing environmentally safe, total nutrient requirements of a 2-yr 2-crop corn/wheat rotation. Similar research is needed over a longer period of time and for more rotations to confirm these findings. Although the irrigation runoff water constituents sampled were low and considered acceptable for irrigation livestock and wildlife purposes, the runoff water cannot be ascertained acceptable for human consumption from the data in this study. Also, further investigations are needed concerning higher single rates of manure application as well as more and deeper, detailed analyses made of percolated nutrients.

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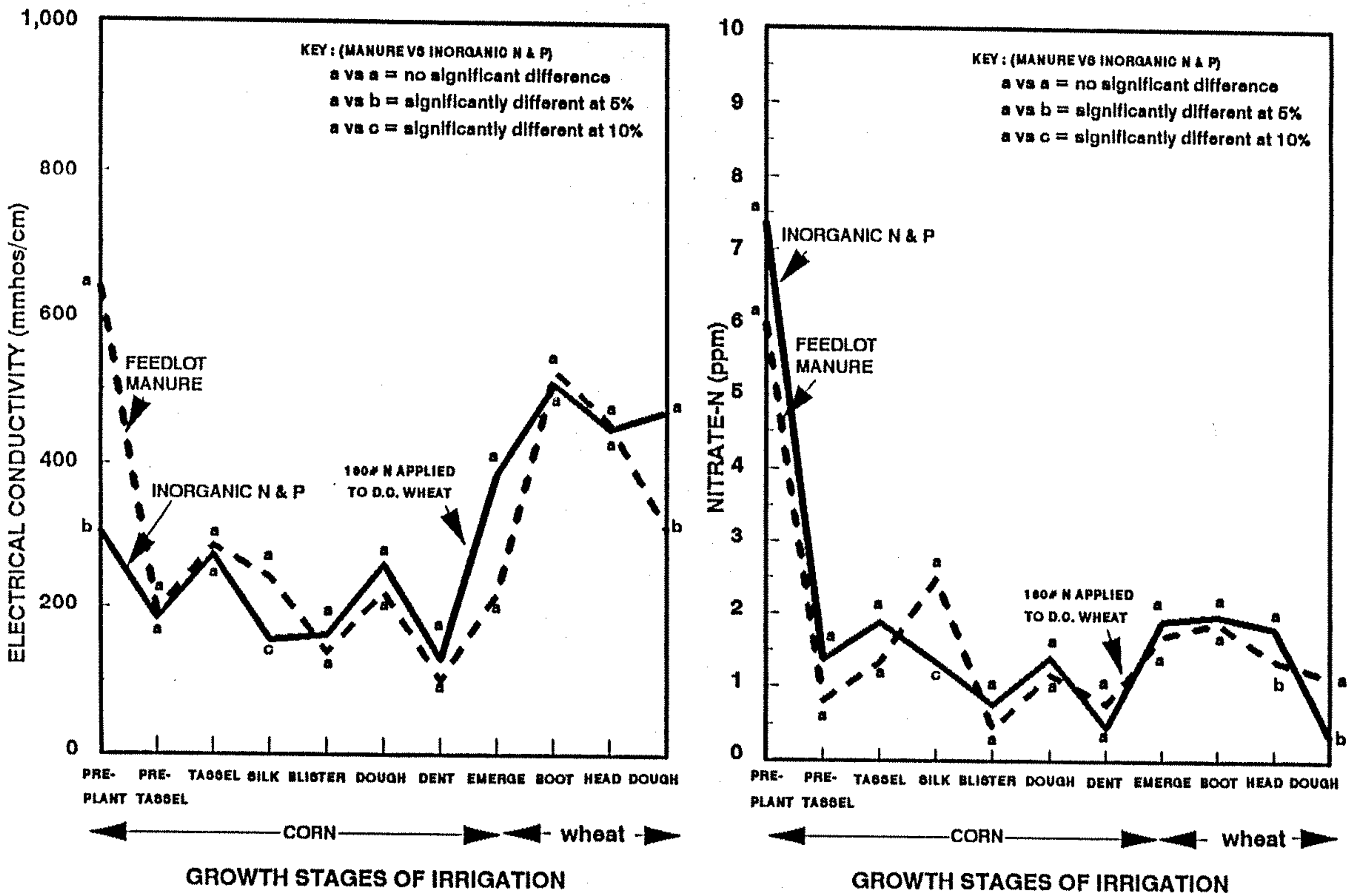

FIG. 1. ELECTRICAL CONDUCTIVITY AND NITRATE-N CONCENTRATIONS (ppm) OF IRRIGATION RUNOFF WATER FOR BOTH '91 CORN AND '91-'92 WHEAT, MANURE VS. INORGANIC FERTILIZERS.

Table 1. Economics of utilizing HLSF feedlot manure (20 tons/ac) versus inorganic N and P fertilizer, corn/double-cropped wheat rotation, southern Great Plains.*

Crop/Item	Feedlot Manure	Inorganic Fert.
Corn:	--------------------$/acre	-------------------
Income, $2.75/bu	$548.72	$548.72
Cost of fertilizer	$60.00[1/]	$144.20[2/]
Application of P	------	5.00
Incorporation, $5 ea.	10.00	5.00
Irrigation cost	73.20	71.64
Wheat:		
Yield/ac	71.7	90.8
income @ $4/bu	286.80	$363.20
Cost of fertilizer	------	18.00[3/]
Irrigation cost	50.12	48.10
Interest @ 9%	18.29	17.98
Subtotal: corn/wheat*	$623.91	$619.98
Difference in residual value (4' soil depth) of:		
N, $0.10/lb	------	(4.48)
P, $0.35/lb	(75.60)	---

* Reflects only the affected cost items and does not represent all costs.

1/ $3/ton delivered and spread.

2/ 392# N/ac @ $0.10/lb applied plus 300# P/ac @ $0.35/lb not applied.

3/ 180# N/ac @ $0.10/lb applied.