TEXAS

Rainfall and Runoff Water Quality from Croplands in the South Texas Coastal Plains

By Bobby R. Eddleman

Management practices used to produce crops (cotton, sorghum, corn) in the south Texas Coastal Plains are highly effective in limiting loads and yields of nutrients and pesticides in runoff.

The study area, called the Odem Ranch Watershed, encompassed 2,775 acres of cropland located near Edroy in western San Patricio County within the Nueces River Basin Drainage Area (**Figure 1**). Water-quality components were assessed for nutrients, pesticides, organic materials, and inorganic ions from rainfall and runoff. The scope of the study included types, concentrations, loads, and yields for nutrients in rainfall and runoff, along with selected pesticides in runoff. Rainfall samples were collected for 19 rainfall events of 0.25 inch or more during May 1, 1996 through December 31, 1997. Rainfall and runoff water samples also were collected for each storm event producing runoff from the watershed during 1996-1999. Total N and P were determined in rainfall samples. Total N and P, organic materials, selected pesticides, and inorganic ions were determined for runoff water samples. Event mean concentrations (EMCs), loads, and yields of nutrients and pesticides were quantified.

Rainfall and runoff water samples were collected from a 2,775-acre watershed used to produce crops. The samples were analyzed for water-quality constituents during 1995-1999. Loads and yields of nutrients...nitrogen (N) and phosphorus (P)...and pesticides (herbicides, insecticides, growth regulators, harvest aids) in runoff were minute in relation to nutrients and pesticides applied to crops. Croplands served as a sink for both N and P deposition in rainfall. Over five times more N in the form of ammonia (NH_3) and nitrate (NO_3) was deposited in rainfall than exited the watershed primarily as particulate organic N and NO_3 in runoff. Twice as much P was deposited in rainfall than exited the watershed as particulate P in runoff.

Hydrology

Rainfall and runoff from the watershed during the study period generally reflected the longer term rainfall pattern for the region, with runoff events interspersed between long periods when no runoff occurred. Cumulative rainfall and runoff for the watershed are shown in **Figure 2**. Rainfall totaled 109 inches during June 1995-May 1999. Seven rainfall events resulting in runoff at two sampling sites produced 5 inches (1,150 acre-ft) of runoff over four years. Runoff during storm events averaged 15 percent of rainfall and ranged from an average of less than 3 percent during the crop growing season (March-June) to an average of 22 percent during harvest and fall (August-October). However, runoff as a proportion of total rainfall on the watershed during June 1995 through May, 1999 was only 4.5 percent. Overall, four rain events with rainfall in excess of 4 inches and accounting for 23 percent of total rainfall on the watershed produced 84 percent of total runoff.

Rainfall Deposition

Deposition of rainfall constituents is the product of EMC for a constituent and rainfall volume. Deposition was measured in pounds per acre.

Nitrogen in rainfall occurs primarily as dissolved ammonia (NH_3) and dissolved nitrate (NO_3) which were detected in all rainfall samples (**Table 1**). Rainfall deposited an annual average of 3.0 lb of total N/A compared to 82 lb N/A/year applied to crops as N fertilizer, or about 3.5 percent of N input to croplands in the watershed.

Total P deposited on the watershed in rainfall amounted to 0.31 lb/A/year compared to 18.5 lb/A applied annually to crops as fertilizer.

TABLE 1. Annual N and P rainfall deposition, 1996-1998.

Constituents	1996	1997	1998	Average 1996-98
	lb/A			
Total nitrogen (as N)	2.10	3.86	3.12	3.03
Ammonia nitrogen (as N)	1.09	2.01	1.61	1.57
Nitrate-nitrogen (as N)	0.79	1.45	1.17	1.14
Total phosphorus (as P)	0.20	0.37	0.35	0.31
Orthophosphate (as P)	0.06	0.09	0.09	0.08

TABLE 2. Statistical summary of nutrient concentrations in runoff.

Constituents	Number of samples	Mean	Median	Maximum	Minimum
		ppm			
Total nitrogen (as N)	8	1.94	2.09	2.74	0.98
Ammonia nitrogen (as N)	10	0.08	0.05	0.24	<0.015
Nitrate-nitrogen (as N)	10	0.08	0.04	0.26	<0.01
Nitrate + nitrite-nitrogen (as N)	10	0.63	0.56	1.18	0.05
Ammonia + organic nitrogen, dissolved (as N)	8	0.38	0.41	0.64	<0.10
Ammonia + organic nitrogen, total (as N)	8	1.32	1.31	2.10	0.69
Total phosphorus (as P)	10	0.51	0.48	0.87	0.27
Dissolved phosphorus (as P)	8	0.26	0.24	0.45	<0.05
Orthophosphate, dissolved (as P)	10	0.24	0.25	0.41	<0.01

Concentrations of Nutrients and Pesticides in Runoff

Nutrient concentrations expressed as parts per million (ppm) were analyzed by computing summary statistics of the data to characterize cropland runoff-event concentrations (**Table 2**). None of the maximum values for nutrient concentrations listed in **Table 2** in runoff from the watershed exceeded any Texas Natural Resources Conservation Commission (TNRCC) standards or U.S. Environmental Protection Agency (EPA) drinking water quality standards.

Figure 1. Odem Ranch Watershed location.

Sixteen pesticides (10 herbicides and six insecticides) were detected with varying degrees of frequency in runoff samples. The

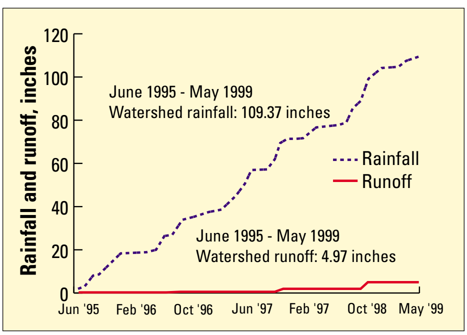

Figure 2. Odem Ranch Watershed monthly cumulative rainfall and runoff, June 1995-May 1999.

herbicide atrazine was detected in all samples. By-products deethyl atrazine and deisopropylatrazine were detected in 90 percent and 60 percent of samples, respectively.

Other herbicides detected in 50 percent or more of samples were metolachlor, trifluralin, fluometuron, and pendimethalin. Insecticides detected in 25 percent or less of all samples were malathion, azinphosmethyl, diazon, methyl parathion, and carbofuran.

TABLE 3. Annual nutrient and pesticide runoff yield, 1996-1998.

Constituents	1996	1997	1998	Average 1996-98
	lb/A			
Total nitrogen (as N)	0.162	0.667	0.800	0.54
Ammonia nitrogen (as N)	0.007	0.014	0.029	0.017
Nitrate + nitrite-nitrogen (as N)	0.061	0.272	0.104	0.146
Ammonia + organic nitrogen, total (as N)	0.088	0.396	0.725	0.403
Total phosphorus (as P)	0.038	0.147	0.261	0.149
Orthophosphate, dissolved (as P)	0.026	0.072	0.051	0.050
Atrazine + deethyl atrazine, dissolved	0.000228	0.000060	0.000055	0.000114
Fluometuron, dissolved	0.000086	0	0.000008	0.000031
Total other pesticides, dissolved[1]	0.000022	0.000035	0.000024	0.000027
Total pesticides	0.000336	0.000095	0.000087	0.000172

[1]Other pesticides consisted primarily of malathion, metolachlor, trifluralin, and pendimethalin in minute quantities.

Atrazine concentrations did not exceed EPA maximum contaminant levels (MCL) of 11 micrograms per liter, equivalent to 11 parts per billion (ppb), for human health and aquatic life protection. Maximum EMC values for all chemical constituents in runoff were less than EPA and TNRCC values for aquatic life and human health protection.

Constituent yield in runoff is the mass of a given constituent transported past a site during a specific time divided by drainage area of the watershed, measured in pounds per acre. Annual yields for nutrients and pesticides in runoff are provided in **Table 3**.

Total N yield ranged from 0.16 lb/A in 1996 to 0.8 lb/A in 1998, with a 1996-98 average of 0.54 lb/A/year. Total P yield averaged 0.15 lb/A/year during 1996-98.

Nitrogen applied as fertilizer far exceeds all other inputs to croplands in the watershed. Average annual fertilizer applications were 82 lb/A over the 1996-98 period compared to 3 lb/A from rainfall deposition and 0.54 lb/A in runoff.

Nitrogen in runoff represents 0.6 percent of N applied to crops as fertilizer and rainfall N. Forms of N entering the watershed differ from forms of N exiting it in runoff. Fertilizer N is applied as NH_3 and NO_3. Rainfall N consists primarily of NH_3 and NO_3. Runoff N is primarily (about 71 percent) organic N, and the organic N is primarily in particulate form (crop residue) rather than dissolved organic N.

Phosphorus applied as fertilizer to cropland averages 18.5 lb/A/year. Additional P, 0.31 lb/A/year, is deposited in rainfall. Phosphorus is applied as soluble orthophosphate. Total P yields in runoff from the watershed averaged 0.15 lb/A/year, with about a third as orthophosphate. Most P in runoff was in particulate form associated with crop residue and soil particles from soils that are naturally high in P content. Total P in runoff amounted to about 0.8 percent of combined P deposition in rainfall and applied orthophosphate to crops in the watershed.

Yield in runoff of all pesticides averaged 0.00017 lb/A/year. Total pesticide residues in runoff were quite small in all years, amounting to less than 1.0 lb for the entire 2,775-acre watershed. By comparison, 5.63 lb/A/year were applied to crops as insecticides (3.53 lb), herbicides (1.52 lb), and growth regulators and harvest aids (0.58 lb) over the 1996-98 period.

Data collected from seven storm events producing runoff during the June 1, 1996 through March 1999 period are representative of nutrient, pesticide, organic matter, and inorganic ions found in surface water runoff from croplands in the south Texas coastal plains. Loads and yields of nutrients and pesticides in runoff were minute in relation to nutrients and pesticides applied to cotton, sorghum, and corn crops. Nitrogen and P in runoff are comprised primarily of particulate organic N and particulate P from crop residues, whereas N and P applied to crops are NH_3 and NO_3-N and soluble orthophosphate.

Croplands serve as a sink for both N and P deposition in rainfall. Over five times more N in the form of NH_3 and NO_3 was deposited in rainfall than exited the watershed, primarily as particulate organic N and NO_3 in runoff. Twice as much P was deposited in rainfall than exited the watershed in runoff.

Changes in tillage practices, crop rotations, row spacings (e.g., ultra-narrow row plantings), plant populations, and amount of crop residue left in the soil have different implications for water quality in runoff since loads and yields of particulate organic N and particulate P may vary with cultural practices. However, results from this study and a companion study for southern Nueces and northern Kleberg counties indicate that with current production practices, crop agriculture poses little risk to the coastal environment in this area. BC

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Alfalfa Yield Response...*(continued from page 19)*

sustain a P-rich environment that supports higher yields in the sixth year.

Potassium fertilizer also resulted in increased yields over the length of the experiment. The 200 lb P_2O_5/A/2-yr rate in conjunction with 500 lb K_2O/A/yr rate yielded the highest of all treatments over the six years (**Figure 4**). This response was somewhat surprising since the initial soil test of 326 lb/A was near the calibrated adequate level (K>350 lb/A), and the comparison treatment received 1,500 lb K_2O over the six-year period. Apparently, alfalfa responds to higher levels of available soil K in a high yielding environment. This statistically significant response of about 3 tons/A (value about $240) was from an input of an additional 1,500 lb K_2O (cost about $165) and would merit economic consideration. It is possible that lower annual rates (e.g. 250 to 300 lb K_2O/A) might have also supported this maximum yield and that the yield difference would have been even larger compared to a no-K treatment, not included in our study. Sulfur fertilization only slightly affected yield over the six years of the trial period.

Initial soil test levels are reported in **Table 1**. Final P soil test levels in the 600 lb P_2O_5/A initial treatment plots (both broadcast and injected) were significantly lower than treatments receiving annual and biennial P applications (**Table 2**). Soil test-P was significantly lower in the unfertilized check than for all other treatments. As expected, the treatment receiving 500 lb K_2O/A/yr had the highest K soil test value, while other plots which received only the initial and two subsequent 500 lb K_2O/A blanket treatments still had higher than what is commonly considered adequate levels of K in the soil (**Table 2**).

The response of alfalfa to high dose P fertilization has important economic implications. If a producer is able to maximize yields over a six-year period by supplying the fertilizer as a single event, additional profit may be realized because the implement and labor costs are decreased due to fewer fertilizer applications. It is important to note these yield responses of alfalfa to P and K fertilization may be unique to high yielding environments (e.g. irrigated areas). BC

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