TRAPPING FUNCTION OF GRASSED FILTERS

William O. Thom

INTRODUCTION

The potential to contaminate rivers, streams, and other natural water bodies with sediment, nutrients, pesticides and bacteria in runoff from agricultural land is a very important water quality issue. Conservation tillage has proven to be effective in decreasing soil exposure to rainfall, thus decreasing water runoff and erosion potential. Vegetative filters slow down runoff that allows sediment, nutrients, pesticides and bacteria to be deposited. Combining conservation tillage with vegetative filters downslope from cropped fields should combine the advantages of both for maximum contaminant removal.

METHODS

This paper will report the results of three studies on sediment, nutrient, pesticide, and bacteria movement from crop land and trapping by vegetative filters. The first erosion studies were started in 1989 with three tillage treatments (no-till, chisel-plow and conventional moldboard) to determine runoff water volume, sediment losses, and certain pesticide losses on an area with 9% slope. Nitrogen (150 lb N/A) as ammonium nitrate and phosphate (40 lb P/A) as triple superphosphate were broadcast 24 hr before rainfall was applied. Atrazine was sprayed at 2 lb a.i./A the day before rainfall. A rainfall simulator applied 2.5 in per hr (a 10 yr rainfall) for 2 hr total (1 hr rain, 24 hr rest, 30 min rain, 30 min rest, and 30 min rain). Runoff was collected at the end of each plot.

In 1990, trapping efficiency of filter strips consisting of a natural mixture of Kentucky Bluegrass and fescue sod was studied following two simulated rainfall events (2.5 in/hr) for 2 hr each on the crop areas. Filter strips were either 15, 30 or 45 ft in length handling runoff from two tillage treatments (no-tillage and conventional tillage). The tillage areas received 150 lb N/A as ammonium nitrate, and 2 lb a.i. atrazine/A just before the first of two simulated rainfall events that occurred three weeks apart.

In 1992 and 1993 the 15 and 30 ft grassed filters were used to determine bacteria trapping efficiency when the cropped plots received 4.5 tons/A of poultry manure that was incorporated with a chisel plow and disc before simulated rainfall of 2.5 in per hr.

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Table 1. Runoff volumes and sediment losses as affected by tillage and rainfall events.

Tillage system	R1	R2	R3	Total
		Runoff volume, inches		
NT	- - -	.05	.25	.30a
CP	.12	.32	.70	1.14b
CT	.37	.60	.80	1.77b
		Sediment loss, tons/acre		
NT	- - -	0.0	.13	.13a
CP	.22	.62	.67	1.51b
CT	1.47	2.27	3.17	6.91c

NT = no-tillage; CP = chisel-plow; CT = conv. tillage
Totals followed by different letters are significantly different ($P<0.05$).

RESULTS

In the first study, total runoff volume and total sediment losses were reduced with decreased tillage intensity (Table 1). The NT system had significantly lower runoff and sediment than either the CP or CT tillage. During the first simulated rain event (R1), the NT system had no runoff and thus no sediment. Also, during the second rain event (R2), the NT system had some runoff but no sediment was lost. Compared with CT, the NT system reduced sediment by 98%, and the CP system reduced it by 79%.

Conventional tillage (CT) had the highest runoff and sediment loss with the CP system being intermediate but not significantly different in runoff volume.

Total losses of nitrate-nitrogen, ammonium nitrogen, soluble phosphate, and atrazine were smaller from the NT system than from either the CT or CP systems (Table 2). This was attributed to the smaller runoff volumes from NT. No-tillage reduced the total losses of nitrate-nitrogen by 86% and 71% compared with CT and CP, respectively.

There were significant differences ($P <.10$) in ammonium-nitrogen between tillage treatments. The NT system reduced ammonium-nitrogen by 22% compared with CP and 57% compared with CT.

Total phosphorus loss was greatest from CT even though concentration was highest from the NT system (data not shown). The greater phosphorus loss from CT was the result of more runoff. The total phosphorus loss from CT was 172% and 248% of the total lost from the CP and NT systems, respectively. The total phosphorus lost from CT represented less than 2.0% of the fertilizer phosphorus applied.

Table 2. Nitrate, ammonium, phosphate and atrazine losses in runoff as affected by tillage and rainfall.

Tillage system	R1	R2	R3	Total
		Nitrate-nitrogen loss, lb/A		
NT	- - -	.09	.36	.45a
CP	.27	.45	.80	1.52b
CT	.98	1.07	1.16	3.21c
		Ammonium-nitrogen loss, lb/A		
NT	- - -	.09	.36	.45A
CP	.27	.18	.27	.72B
CT	.45	.36	.27	1.08C
		Phosphorus loss, lb/A		
NT	- - -	<.01	.27	.28
CP	.09	.09	.18	.36ab
CT	.27	.18	.18	.63b
		Atrazine loss, g/A		
NT	- - -	1.4	5.4	6.8a
CP	4.2	3.1	4.7	12.0ab
CT	10.9	2.6	3.1	16.6b

(Rainfall event: R1, R2, R3)

NT = no-tillage; CP = chisel plow; and CT = conv. tillage. Totals followed by small letters are significantly different at P <.05 and totals followed by capital letters are significantly different at P <.10.

Total atrazine loss was greatest from CT which was attributed to the greater runoff volume. On the average, NT reduced atrazine losses by 43% compared with CP losses and 60% compared with CT.

In the grassed filter strip trapping efficiency studies, the tillage treatments greatly influenced the amount of sediment lost (Table 3). These results are

Table 3. Tillage system effects on sediment and runoff losses from cropped plots.

Tillage system	Rainfall event	Sediment losses	Water losses
		tons/A	in/A
CT	1	5.78	0.24
	2	12.18	3.62
	Total	17.96	3.86
NT	1	1.12	1.50
	2	1.46	1.87
	Total	2.58	3.37

consistent with the earlier study in that NT is an effective erosion control practice especially when compared to the conventional moldboard plow system (CT).

The grass filter strips were very effective in trapping sediment, nitrate-nitrogen, and atrazine (Table 4) when channelization was not present. The 30 ft filter strips were more effective in filtration ability with time than the 15 ft filter strips which was attributed to the greater length and area. However, the development of rivulets in the 45 ft filter strips directed the runoff into a few prominent small channels which decreased the trapping efficiency of these longer strips for water and atrazine (Table 5). Even though nitrate containing fertilizer was broadcast just before simulated rainfall, there was very little of this water-soluble component leaving the filter strip regardless of length. Overall, the 30 ft filter strips had greater trapping efficiency for sediment, water, nitrate-nitrogen, and atrazine. However, the most effective combination of tillage system with length was NT with a 45 ft filter strip (data not shown). When channelization is minimized, the 45 ft filter strip should prove to be the most effective for runoff during a crop growing season.

Table 4. Trapping efficiency of grassed filter strips, amount lost from cropped plots remaining on filters.

Filter width	Rainfall event	Sediment	Water	Nitrate-nitrogen	Atrazine
		- - - - - - % trapped - - - - - -			
15 ft	1	98	96	93	93
	2	95	96	95	93
	Mean	96	96	94	93
30 ft	1	99	99	99	99
	2	99	95	96	99
	Mean	99	97	98	99
45 ft	1	99	91	97	98
	2	99	90	97	97
	Mean	99	91	97	98

Table 5. Amount of applied nitrate-nitrogen and atrazine lost in runoff from filter strips.

Filter width	Rainfall event	Nitrate-nitrogen	Atrazine
15 ft	1	0.7%	1.3%
	2	0.3%	0.3%
	Mean	0.5%	0.8%
30 ft	1	< 0.1%	< 0.1%
	2	3.2%	< 0.1%
	Mean	1.6%	< 0.1%
45 ft	1	0.3%	6.3%
	2	< 0.1%	0.9%
	Mean	0.2%	3.6%

Since much of the animal waste will be land applied, the third group of studies involved an assessment of using filter strips to trap bacteria from surface application of poultry manure. Without good practices for trapping bacteria, these pollutants can potentially move into streams, or other natural water bodies. Relatively little is known about the trapping efficiency of grass filter strips for fecal bacteria.

Table 6. Sediment, fecal coliform and fecal streptococci trapping in surface runoff by grassed filters.

Filter length	Plot No.	Sediment	Fecal coliforms	Fecal streptococci
		- - - - - - - % trapped - - - - - - -		
15 ft	1	97.2%	95.0%	91.9%
	2	93.1%	50.0%	23.1%
30 ft	3	99.1%	74.0%	29.4%
	5	98.9%	43.0%	nd

nd = not determined

The 15 and 30 ft filter strips were very effective in removing sediment in surface runoff from these poultry manured plots (Table 6). It again demonstrates what the two earlier studies indicated, that filter strips could effectively remove sediment from surface runoff going into surface water bodies.

Fecal bacteria trapping was a lot more variable than sediment trapping. The 15 ft filter strips were more variable than the 30 ft strips. From 43% to 95% of the fecal coliform bacteria were trapped while 23.1% to 91.9% of fecal streptococci were trapped.

Although the grass filter strips trapped most of the fecal bacteria in the runoff, the concentration of fecal bacteria remaining in the runoff from the filter strips was greater than 2000 colony forming units per 100 ml. This is considerably higher than the primary contact standard for water of 200 colony forming units per 100 ml indicating that the grass filter strips did not reduce manured plot runoff to these standards. This study used intense rainfall shortly after manure application and incorporation to cause surface runoff. The longer the interval between manure application (followed by incorporation) and rain, the lower the fecal bacteria populations in the soil become.

CONCLUSIONS

1. As tillage intensity was reduced in these studies, runoff water and sediment are significantly decreased (conventional tillage > chisel-plow > no-tillage).

2. Losses of nitrate-nitrogen, ammonium-nitrogen, phosphorus, and atrazine from cropped areas decrease with decreased tillage intensity.

3. The 30 ft grass filter strips were more consistent than either 15 ft or 45 ft strips in reducing water volume, sediment, nitrate-nitrogen and atrazine in surface runoff from cropped areas regardless of tillage system.

4. Grassed filters gave mixed results in removing fecal bacteria from runoff of manured fields. Even though fecal bacteria are reduced up to 95%, filter strip runoff contains bacteria levels in excess of the primary contact standard for water.

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