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COMPETITIVE GRANT REPORT
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Buffer strips for controlling herbicide losses

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Budget
$15,327 for one year

Background

Buffer strips are considered effective for reducing runoff of sediment and agricultural chemicals from cropland. In fact, buffer strips, or vegetative filter strips, have been suggested as a Best Management Practice to reduce nonpoint source pollution from cropland. This pollution can be great, especially if rainfall occurs shortly after a chemical has been applied.

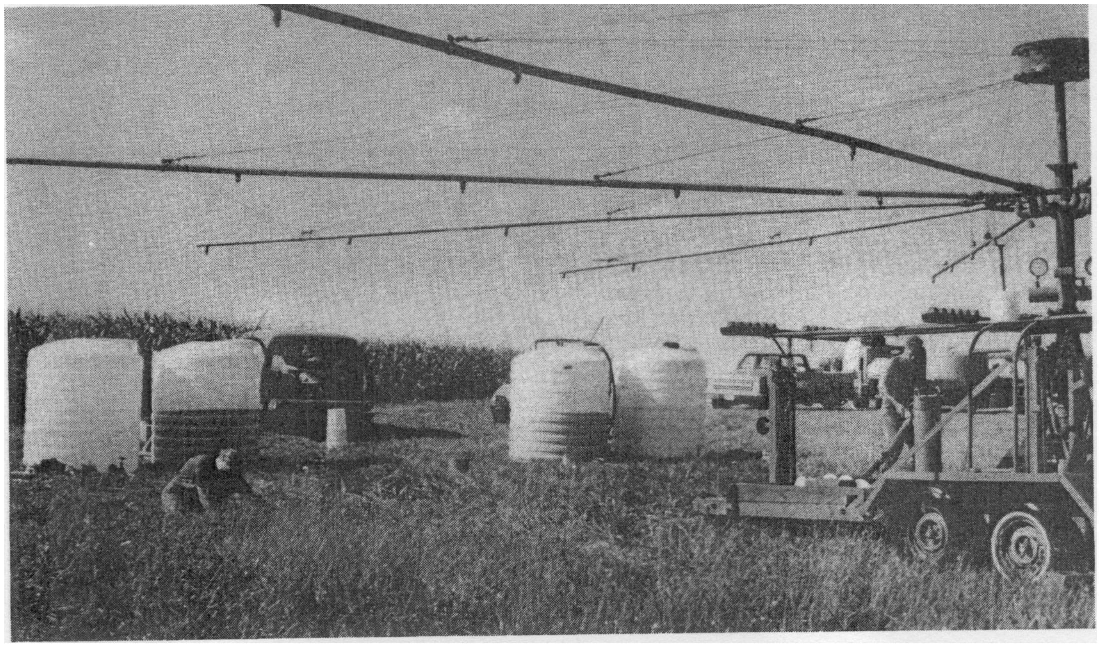
Buffer strips are bands of vegetation located down-slope of cropland, animal feed lots, or other potential pollutant sources. The purpose of these strips is to provide erosion control and to filter nutrients, pesticides, sediment, and other pollutants from agricultural runoff by reducing the sediment carrier, as well as to mitigate pollution through interception-adsorption, infiltration, and degradation of pollutants dissolved in the runoff water. Although significant research has been conducted on various aspects of buffer or filter strips, little research has been conducted on runoff loss of pesticides from cropland when these strips are used. Most of the investigations have examined nitrogen, phosphorus, and sediment removal by the vegetated filter strips. Research on the use of filter strips as an effective way to reduce chemical losses to surface runoff—and thus to streams or sinkholes—is necessary, especially with new pesticide labels sometimes requiring buffer strips.

The objectives of this research project were to determine
(1) the effects of grassed buffer strips on sediment and herbicide losses from conventional and no-tillage cropland, and
(2) the effects of 4.6-meter (m) and 9.1 -m (15 feet and 30 feet) buffer strips on the sediment and runoff losses from conventional and no-tillage cropland.

Approach and methods

Twelve buffer strip plots were laid out on previously established grassed areas. Six of the plots were 1.5 m x 4.6 m long; the other six were 1.5 m x 9.1 m long. Plots were isolated with metal borders; investigators installed collectors at the down-slope end for manual sample collection and flow measurement. Covers placed over the collectors kept additional rainfall from entering the runoff water and diluting the samples. A randomized block design was used with three replications of each treatment. Plot slopes averaged 4.6%; the range was 3 to 6%. Grasses consisted of 59% smooth brome, 35% Kentucky bluegrass, and 6% Kentucky 31 tall fescue. There was an average of 1,046 tillers, or shoots, per m^2 (97 tillers/ft^2) with an average height of 29.5 centimeters (cm) (12 inches).

Simulated rainfall was applied at an intensity of 6.5 cm (2.6 in.) per hour (h) on a block of four plots at a time. Inflow was metered into the upper ends of the plots (at a herbicide concentration of approximately one part per million for atrazine) and evenly distributed by using a 6.4-cm diameter x 1.5-m long polyvinyl chloride (PVC) pipe with holes drilled every 7.6 cm along its length. This simulated runoff onto the plots represented a 10:1 area ratio of contributing area to buffer area for the 4.6-m plots and a 5:1 area ratio for the 9.1 -m plots. Flow rate meters measured the inflow before it reached the plots. Sediment was added to and mixed with the conventional tillage inflow (-10,000 parts per million) by pumping the sediment-water mixture in a 2,000-liter (500-gallon) polyethylene cylindrical tank (see photo). Water and sediment circulated continuously during the rainfall event. No-tillage inflow was also stored in 2,000-liter tanks, but no sediment was added.



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Water and/or sediment were added to the plot using gravitational flow. Inflow was added to represent runoff from an area at 2.5 cm/h (1 in./h) for approximately 50 minutes following 10 minutes of "wetting" rain.

The investigators collected three inflow samples (each integrated over 15 minutes [min.]) and 10 outflow samples (each integrated over five min.) for each plot. Weight-time readings were taken to measure outflow rate before and after each sample interval; inflow rate readings were taken from flow rate meters at the same time.

Samples were immediately refrigerated at 5°C (41°F) after collection. Shortly thereafter, each sample was vigorously shaken, after which a small portion was removed for sediment concentration determinations; these were made by slightly modifying standard drying/gravimetric procedures used for measuring total solids.

Soil moisture samples were also taken prior to each rainfall event at three depths: 0-15 cm (0 to 6 in.), 15-30 cm, and 30-45 cm. Four samples total were taken among the plots; average moisture content at the first depth was 27.7%; it was 23.2% and 23.4% respectively for the second and third depths.

The same procedures were used for extracting the no-tillage water samples and the conventional-tillage water samples except that slightly more dichloromethane (an organic solvent) was used for the conventional-tillage samples. Investigators analyzed these extracts with a chromatograph equipped with a thermionic detector. Column oven temperature was held constant at 160°C with an inlet temperature of 246°C and a detector temperature of 246°C.

For each of the three replications of each treatment, investigators calculated percent removal of atrazine in overland flow by the buffer strips. Percent reduction in sediment after it passed through the buffer strips was also calculated for the conventional tillage plots.

Findings

Hydrology: Investigators recorded the total rainfall, inflow, outflow, and infiltration data for the 12 rainfall simulation buffer-strip plots. The desired rainfall was 6.6 cm, although this amount varied because light winds and other factors created minor disturbances. Inflow onto all the plots, while intended to be constant at about 30 liters (L)/min., also varied. In general, the inflow flow rate for each plot decreased slightly with time as the head in the supply tank decreased with amount in the tank.

A constant volume of inflow over a 4.6-m long plot resulted in an equivalent depth of water twice that for the same volume over a 9.1-m long plot.

Infiltration in the vegetated buffer-strip plots was calculated by subtracting outflow from the sum of inflow and rainfall inputs. Allowing for the "scatter" typical with these types of measurements, there were no differences—nor were any expected—between the treatments, either with and without sediment or for the 4.6-m and 9.1-m lengths. On the average, infiltration exceeded the rainfall input by 16% or 1.1 cm. This additional infiltration, extracted from the inflow, represented 7% of the inflow for the 4.6-m plots; for the 9.1 -m plots, it would represent 16% of the inflow (this approximate factor-of-two difference was expected on the basis of the constant inflow and twice the infiltration area for the 9.1-m long plot). Any decrease in herbicide transport beyond these values therefore would have to be explained by processes other than infiltration.

Investigators also measured the inflow-outflow relationships for a typical plot as a function of time. A dye tracer revealed that travel time for the 4.6-m long plots at the end of a simulation was about 120 seconds; for the 9.1-m plots, it was about twice that.

Sediment trapping: For plots with sediment in the inflow, vegetated buffer strips were very effective in trapping sediment out of the flow. The average height of the grass was 30 cm. An average of 72.2% of the sediment entering the 4.6-m long plots was trapped; for the 9.1-m long plots, the average was only slightly greater at 75.7%. Casual observation of sediment deposition in the buffer strips suggested that a large portion of it took place in the first 1 m of the plot (see Fig. 1).

Herbicide removal: On the average, the 4.6-m long buffer strips removed 35.0% of atrazine in solution in the inflow without sediment; for the 9.1-m long buffer strips removal was higher, at 59.5%. For the treatments that included sediment in the inflow,, the corresponding values were 28.3 and 51.3% removal (see Fig. 2). Surprisingly, the herbicide removal with sediment present in the inflow was slightly lower than for inflow without sediment, despite sediment trapping or removal (and removal of herbicides adsorbed onto the sediment) of over 70%.

However, in either case, the percentage of herbicide removal far exceeded the percentage of outflow reduction as a result of infiltration. Thus, the attenuation processes of adsorption to in-place soil, living vegetation, dead bio-

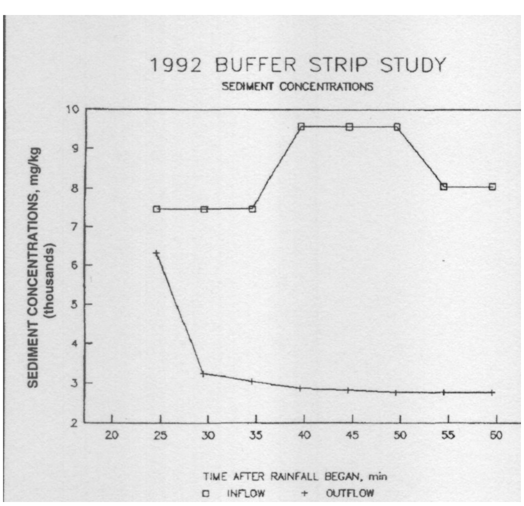

Fig. 1. Sediment concentrations in inflow and outflow for 4.6-m conventional tillage plot, replication 2.

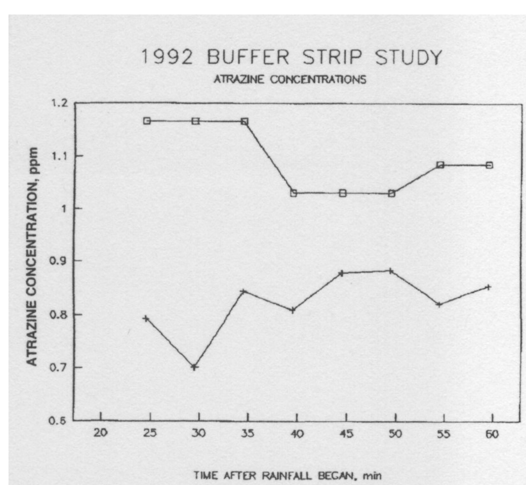

Fig. 2. Concentrations of atrazine in inflow and outflow for the 4.6-m conventional tillage plot, replication 2.

mass, or some other unknown process must be significant in causing herbicide removal.

No significant difference was found in atrazine reduction between the no-tillage and conventional tillage plots. The 4.6-m length and the 9.1-m lengths reduced atrazine losses by 31.7% and 55.4% respectively.

Implications

A 4.6-m buffer strip decreased sediment by 72%, but sediment was not further reduced to any significant degree by doubling that buffer length. The longer buffer length did a better job of reducing atrazine losses than did the shorter length. If the drainage area far exceeds the buffer strip area (e.g., >100:l), the effectiveness would be much reduced; likewise, if flow is concentrated in only a small portion of the buffer strip, effectiveness would be reduced. *Atrazine loss reduction was not significantly different between no-tillage and conventional-tillage plots.*

Although the previous work involved mostly studies of small plots below cropland and feed lots, these results can be applied to buffer strips along stream banks, field borders, waterways, or in fields that are contoured. As found in this and other research projects, buffer strips along banks should be effective in reducing sediment, nutrient, and pesticide losses, as well effectively reducing erosion of the stream boundaries. Vegetation at the edge of a field can be used to control erosion and to protect the edge of fields that are used as turn rows or travel lanes for farm machinery. Currently, many farmers are using grassed waterways to reduce erosion from areas that may be susceptible to rill or gully erosion. Grassed waterways have already been proven effective for erosion control (provided the slope is not so large that it causes erosion next to the waterway or damage to the waterway). Recent articles in the popular farm press have described how farmers are using contour buffer strips to meet their conservation compliance plans. These contour buffer strips are inexpensive, easy to install, and versatile. It is also possible to use them for hay, set-aside acres, or grazing.

A survey conducted by *Iowa Farmer Today* ("Survey shows farmers need help with sinkholes," January 6, 1990, Cedar Rapids, Iowa, p. 9) asked 107 farmers from Allamakee, Clayton, Winneshiek, Fayette, and Mitchell counties about the issue of runoff losses to sinkholes. Of these farmers, 95% had sinkholes in their fields. Sinkholes form when water moves through shallow surface soil into fractures of limestone bedrock and dissolves the limestone, causing voids below the surface. Eventually, these voids enlarge until a collapse occurs and unfiltered surface runoff enters this opening. Farmers rated permanent forage as the best method for effectively preventing nutrient and pesticide losses into the sinkholes. Permanent filter strips were rated the third most acceptable way to treat sinkhole problems. Of the current practices being used, filter strips were currently being used by 36% of those surveyed. This constitutes evidence that filter strips are being used, and that farmers would be willing to use filter strips in order to reduce nutrient and pesticide runoff losses to sinkholes or for other problems caused by nonpoint source pollution.

Additional research is necessary on the use of filter strips as an effective way to reduce pesticide losses to surface runoff—and thus to streams or sinkholes—especially with new pesticide labels requiring buffer strips in some cases. Future related research is needed on the effects of grass versus bare buffer strips, high versus low inflow concentrations, and even longer (e.g., 20-m) grass strips.

Results from this study were presented at the Extension agricultural engineering field specialist in-service meeting in March 1993 and at the 1993 National ASAE Summer Meeting held at Spokane, Washington. Preliminary results were also shared with industry in soliciting funding for continued buffer strip research.

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