1-1-2000

Narrow Grass Hedge Effects on Runoff and Soil Loss

John E. Gilley
University of Nebraska - Lincoln, jgilley1@unl.edu

B. Eghball
University of Nebraska - Lincoln

L. A. Kramer
United States Department of Agriculture

T. B. Moorman
United States Department of Agriculture

Narrow Grass Hedge Effects on Runoff and Soil Loss

J.E. Gilley, B. Eghball, L.A. Kramer, T.B. Moorman

Abstract: This rainfall simulation study provided information on the effects of 0.72 m (2.4 ft) wide switchgrass hedges located at the bottom of plots on runoff and soil loss under both no-till and tilled conditions. The study area, which had slopes ranging from 8 to 16%, had produced corn for 33 years and the grass hedges had been established for six years. Simulated rainfall [64 mm hr^{-1} (2.5 in hr^{-1})] was applied for two hours to plots [3.7 m (12 ft) wide by 10.7 m (35.1 ft) long] with corn residue and to plots where corn residue was removed. The narrow grass hedges substantially reduced runoff and soil loss. Under no-till conditions, the plots with corn residue and grass hedges averaged 52% less runoff and 53% less soil loss than similar plots without grass hedges. Under tilled conditions, the plots with corn residue and grass hedges averaged 22% less runoff and 57% less soil loss than comparable plots without grass hedges. The plots with corn residue removed but with grass hedges present averaged 41% less runoff and 63% less soil loss than similar plots without grass hedges. Narrow grass hedges are an effective conservation measure, especially when used in conjunction with such conservation practices as no-till or reduced-till farming systems.

Keywords: Conservation farming, grass filters, no-till systems, reduced-tillage systems, runoff, sediment detention, soil loss

Filter strips have been shown to substantially reduce nutrients and sediment in runoff from cultivated agricultural areas (Dillaha et al. 1989; Magette et al. 1989; Coyne et al. 1995). The effectiveness of filter strips is influenced by runoff rate and length of the vegetative filter, and characteristics of the runoff area (Bingham et al. 1980; Robinson et al. 1996; Daniels and Gilliam 1996). Filter or buffer strips are usually located at the bottom of a hillslope and are typically several meters wide. Runoff entering the filter strips is usually transported from a relatively large upslope area. The effectiveness of filter strips may be reduced substantially under concentrated flow conditions where vegetation becomes submerged or inundated with sediment (Kemper et al. 1992).

Recently, narrow grass hedges, planted on the contour along the hillslope, have been used as a conservation measure (Dabney et al. 1995; Dewald et al. 1996; Raffaelle et al. 1997). Grass hedges are seeded using stiff, erect grasses that promote sediment deposition and berm formation. The broad-grass-backed berms diffuse and spread overland flow. Since grass hedges are placed at relatively short intervals along the hillslope, the potential for concentrated flow is reduced (Meyer et al. 1995). As a result, most of the sediment carried by overland flow along the hillslope usually moves only a short distance before it is deposited.

The use of narrow grass hedges in the United States is a relatively recent conservation practice. Thus, little work has been conducted to evaluate the on-farm performance of narrow grass hedges. The objective of this study was to determine the effect of narrow switchgrass hedges on runoff and soil loss under no-till and tilled conditions.

J. E. Gilley is an Agricultural Engineer with the USDA-ARS located at the University of Nebraska, Lincoln. B. Eghball is an Associate Professor with the Agronomy Department at the University of Nebraska, Lincoln. L. A. Kramer is an Agricultural Engineer with USDA-ARS, National Soil Tilth Laboratory, Deep Loess Research Station, Council Bluffs, Iowa. T. B. Moorman is a Microbiologist with USDA-ARS located at the National Soil Tilth Laboratory, Ames, Iowa.

Materials and Methods

This study was conducted at the USDA-ARS National Soil Tilth Laboratory Deep Loess Research Station approximately 19 km (12 mi) east of Council Bluffs, Iowa. The Monona (fine-silty, mixed, superactive, mesic Typic Hapludolls) soil type in the study area developed on a deep loessal mantle overlying glacial till. Annual precipitation at the study site averages 816 mm (32.1 in) and mean daily temperatures range from -7°C (19°F) in January to 24°C (75°F) in July. The average frost free growing season extends for 145 days, from May through September.

Slopes at the study site ranged from 8 to 16% with a mean value of 12% (see Table 1). Cropped areas with this gradient are typical of the loess hills of southwestern Iowa. Use of proper conservation measures is critical in this region because of steep and long slopes.

The study site had been in continuous corn *(Zea mays L)* since 1964 and had been managed using spring tillage for seed bed preparation and weed control. In May 1991, 0.72 m (2.4 ft) wide switchgrass *(Panicum virgatum)* hedges were established along the slope contour within a 6 ha (15 ac) watershed. The grass hedges were separated by 16 corn rows each with a 97 cm (38 in) spacing. The grass hedges were not always positioned exactly along the contour but were sloped slightly in some sections to maintain the parallel spacing between the hedges required for farming operations.

For effective reduction in downslope sediment transport, the narrow grass hedges must be wide enough to withstand submergence by concentrated flow. However, the region occupied by the grass hedges will reduce the total land area available for crop production. The design, spacing, and lateral extent of the grass hedges are influenced by anticipated runoff rates, topography, crop management and other factors (Kemper et al. 1992). During the six years the grass hedges have been present within the watershed, they have not been seriously impacted by concentrated flow. However, the grass hedges have caused substantial sediment deposition as evidenced by the appearance of berms above the hedges.

The experimental conditions used in this study were selected to measure the effect of narrow grass hedges on runoff and soil loss from the area immediately upslope. Several grass hedges were established at downslope intervals of 15.5 m (50.8 ft) throughout the watershed. Under extreme rainfall conditions, concentrated flow may move from the upper to the lower portion of the watershed, crossing several narrow grass hedges. This accumulating flow condition was not simulated in the present study.

Except for herbicide application, the study area was left undisturbed following corn harvest in the fall of 1996. The grass hedges were mowed to a height of approximately 46 cm (18 in) prior to the rainfall simulation tests, which were conducted in May, June, and July of 1997. Except for mowing in the spring, the grass hedges did not require any additional maintenance. The two uppermost grass hedges in the watershed were used in the study.

Table 1. Slope, residue cover, runoff, and soil loss for the experimental treatments.

Treatment (Mg ha^{-1})	Replication	Tillage Condition	Slope (%)	Residue Cover (%)	Initial Run Runoff (mm)	Initial Run Soil Loss (Mg ha^{-1})	Wet Run Runoff	Wet Run Soil Loss (mm)
Treatments With Corn Residue								
Control With Grass Hedge	1	No-till	13	83	0.5	0.02	10.1	0.44
Control With Grass Hedge	2	No-till	16	76	0.0	0.00	8.1	0.70
Control With Grass Hedge	3	No-Till	12	89	0.0	0.00	1.7	0.03
Control Without Grass Hedge	1	No-Till	13	94	1.7	0.09	20.1	0.72
Control Without Grass Hedge	2	No-Till	14	87	0.0	0.00	16.2	0.62
Control Without Grass Hedge	3	No-Till	14	80	0.0	0.00	9.1	0.76
Control With Grass Hedge	1	Tilled	8	51	0.0	0.00	16.3	0.67
Control With Grass Hedge	2	Tilled	10	32	7.1	0.24	11.6	0.10
Control With Grass Hedge	3	Tilled	13	11	0.0	0.00	12.8	0.59
Control Without Grass Hedge	1	Tilled	12	57	2.2	0.15	11.3	0.50
Control Without Grass Hedge	2	Tilled	13	36	8.9	1.08	37.6	3.46
Control Without Grass Hedge	3	Tilled	15	32	0.1	0.02	19.5	1.30
Fertilizer With Grass Hedge	1	No-till	10	88	0.6	0.04	14.4	0.47
Fertilizer With Grass Hedge	2	No-till	15	76	0.0	0.00	5.4	0.37
Fertilizer With Grass Hedge	3	No-till	11	90	0.0	0.00	2.7	0.07
Fertilizer Without Grass Hedge	1	No-till	11	89	0.2	0.02	13.0	0.73
Fertilizer Without Grass Hedge	2	No-till	16	88	0.4	0.05	20.6	1.07
Fertilizer Without Grass Hedge	3	No-till	12	88	1.0	0.13	7.1	0.29
Fertilizer With Grass Hedge	1	Tilled	10	19	0.0	0.00	4.9	0.10
Fertilizer With Grass Hedge	2	Tilled	10	30	0.0	0.00	25.6	0.58
Fertilizer With Grass Hedge	3	Tilled	15	28	6.1	0.78	34.8	3.06
Fertilizer Without Grass Hedge	1	Tilled	12	56	2.5	0.25	19.8	1.02
Fertilizer Without Grass Hedge	2	Tilled	14	12	2.4	0.20	18.1	0.85
Fertilizer Without Grass Hedge	3	Tilled	14	33	8.3	1.70	27.2	4.31
Manure With Grass Hedge	1	No-till	11	72	0.0	0.00	4.4	0.44
Manure With Grass Hedge	2	No-till	16	64	0.0	0.00	6.2	0.15
Manure With Grass Hedge	3	No-till	11	82	0.0	0.00	3.4	0.21
Manure Without Grass Hedge	1	No-till	14	69	0.0	0.00	11.6	0.59
Manure Without Grass Hedge	2	No-till	14	51	0.2	0.02	19.4	1.12
Manure Without Grass Hedge	3	No-till	12	57	0.0	0.00	0.0	0.00
Manure With Grass Hedge	1	Tilled	9	58	0.0	0.00	10.2	0.77
Manure With Grass Hedge	2	Tilled	10	19	5.2	0.45	23.8	0.43
Manure With Grass Hedge	3	Tilled	11	23	0.0	0.00	11.5	0.43
Manure Without Grass Hedge	1	Tilled	12	50	0.0	0.00	5.1	0.24
Manure Without Grass Hedge	2	Tilled	12	45	5.5	0.46	27.6	1.81
Manure Without Grass Hedge	3	Tilled	15	14	0.0	0.00	22.4	1.55
Treatments Where Corn Residue Was Removed								
With Grass Hedge	1	Tilled	9	3	5.0	0.35	17.0	0.72
With Grass Hedge	2	Tilled	14	7	15.7	4.37	39.1	14.91
With Grass Hedge	3	Tilled	14	3	13.8	2.38	30.3	9.81
Without Grass Hedge	1	Tilled	10	4	34.0	18.28	50.6	19.72
Without Grass Hedge	2	Tilled	10	3	22.7	8.49	27.0	9.41
Without Grass Hedge	3	Tilled	10	5	34.8	19.17	34.7	13.13

The location of the previously established grass hedges dictated the position of the plots along the hillslope. Each of the plots were 3.7 m (12 ft) wide by 10.7 m (35.1 ft) long. The plots were established perpendicular to the slope using sheet metal borders which extended approximately 10 cm (4 in) both above and below the ground surface.

A portable rotating boom rainfall simulator based on a design by Swanson (1965) was used to apply rainfall simultaneously to two plots (Figure 1). The continuously spraying nozzles are mounted on booms, which move in a circular path. The simulator provides near natural rainfall drop size and velocity, and relatively uniform plot coverage. A small stream near the watershed with water having an electrical conductivity of 0.71 mMhos cm^{-1} served as a water supply.

An initial one hour rainfall at an intensity of approximately 64 mm hr^{-1} (2.5 in hr^{-1}) was applied at existing soil-water conditions (initial run). A second one hour application at the same intensity was conducted approximately 24 hours later (wet run). Initial and wet rainfall simulation runs were applied to each plot only once during the study. A 64 mm (2.5 in) rainfall of one hour duration in this area has a recurrence interval of approximately 10 years (Hershfield 1961). Since two 64 mm hr^{-1} (2.5 in hr^{-1}) rainfall simulation events were applied within approximately a 24 hour period, the wet simulation run imposed a runoff event which would occur less than once in 25 years.

Soil samples from depth intervals of 0 to 15 cm (0 to 6 in) and 15 to 30 cm (6 to 12 in) were collected immediately before the rainfall simulation tests at three locations along the perimeter of each plot using a 1.9 cm (0.75 in) diameter coring device. The soil samples were later placed in an oven and dried to determine antecedent soil water content.

Both the no-till and tilled plots were covered with plastic sheets between the initial and wet runs which reduced evaporation to negligible levels so there was little drying and cracking of the soil surface seal. Consequently, the sequences of simulated precipitation events were similar to natural events, with relative humidity approaching 100% during the period between the two events.

The principal experimental variables used in this study included a no-till or tilled soil condition, the presence or absence of a narrow grass hedge, and the use of manure, inorganic fertilizer or a

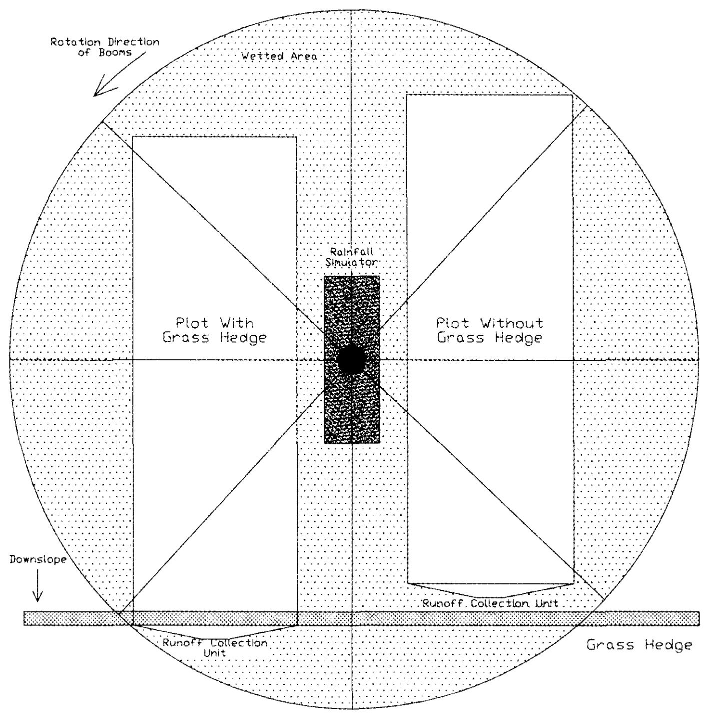

Figure 1. Plot diagram of a rainfall simulation site.

control (Table 1). These variables were selected to represent some of the diverse management conditions used in this region. The manure and fertilizer were spread as evenly as possible by hand over the entire plot at rates required to meet approximate N requirements for a corn crop with a target yield of 9.4 Mg ha^{-1} (150 bu ac^{-1}). The manure used in this study had a total N content of 0.82%, a total P content of 0.55% (dry weight basis), and a water content of 21%. It was assumed that the plant N availability from manure is 40% during the year of application (Eghball and Power 1999). The effectiveness of the grass hedges in trapping nutrients from the plots on which manure and inorganic fertilizer had been applied was examined in a companion study. Results from the nutrient transport investigation are presented in an associated report (Eghball et al. 2000).

The average intensity and amount of simulated rainfall applied to the plots was measured using five direct-reading rain gauges located around the perimeter of each plot. Runoff was collected by a trough which extended across the bottom of each plot and emptied into the approach of a 0.18 m (0.6 ft) HS-flume, which had a precisely constructed throat. The flume was equipped with a stilling well and stage recorder to measure the rate and amount of runoff. Runoff samples were collected at the flume outlet in one liter (one quart) autoclaveable plastic bottles at five minute intervals from the start of runoff to determine total soil loss. The plastic bottles were later placed in an oven maintained at a temperature of approximately 106°C (223°F), which would evaporate the water. Standard procedures were used to calculate runoff and soil loss (Meyer 1960).

Colored slides were taken at three locations on each plot after the second simulation event. The contrast between vegetative material and the soil surface was most pronounced under wet conditions. The resulting slides were projected onto a screen containing a grid and the residue material intersecting the grid points was determined (Mannering and Meyer 1963). The ratio of intersection points over total grid points times 100 was the percentage of the soil surface covered by residue. On those plots with collection units located below the grass hedge, residue cover measurements were made only on that portion of the plot cropped to corn. The grass hedge was not included in the residue cover measurements.

A single disking operation to a depth of approximately 8 cm (3 in) was performed along the contour on the tilled treatments to incorporate the manure and fertilizer which were applied immediately before tillage (Table 1). All of the tilled plots within a treatment block were disked at the same time. Simulation tests were run within a week following tillage. On the no-till plots, manure and fertilizer were applied immediately before the rainfall simulation tests and then left undisturbed on the soil surface.

The portion of the study using corn residue was conducted as a split-plot in a randomized complete block design with three replications. Main plots consisted of no-till and tilled conditions and subplots included the following treatments (Table 1):

1. Manure applied at a rate of 46.4 Mg ha^{-1} (20.7 tons ac^{-1}) (dry weight) without a grass hedge,
2. Manure applied at a rate of 46.4 Mg ha^{-1} (20.7 tons ac^{-1})(dry weight) with a grass hedge,
3. Inorganic ammonium nitrate fertilizer applied at a rate of 151 kg N ha^{-1} (135 lb N ac^{-1}) plus 26 kg P ha^{-1} (23 lb P ac^{-1}) as 18-20-0 (N-P-K) without a grass hedge,
4. Inorganic ammonium nitrate fertilizer applied at a rate of 151 kg N ha^{-1} (135 lb ac^{-1}) plus 26 kg P ha^{-1} (23 lb P ac^{-1}) with a grass hedge,
5. Untreated (control) without a grass hedge, and
6. Untreated (control) with a grass hedge.

Runoff and soil loss measurements with and without grass hedges were obtained from different plots, not from multiple simulation runs on the same plot.

The temperature used to dry runoff samples in the oven was not great enough to volatize the solid material contained in the manure. Both sediment and manure remained in the plastic bottles following drying. Since manure solids are usually a small fraction of the total solids transported from a plot, solid materials carried in runoff were reported as soil loss (Gilley and Eghball 1998).

To test the effectiveness of grass hedges in trapping sediment under highly erosive soil conditions, additional plots were established on an area where corn residue was removed by handraking. The plots were then rototilled to a depth of approximately 13 cm (5 in) immediately before the rainfall simulation tests. Residue cover on these plots, which consisted primarily of small roots, varied from 3 to 7%, with a mean value of 4% (Table 1). This portion of the investigation used a block design with three replications. Plots were established (Table 1): 1.) with a grass hedge and 2.) without a grass hedge. Runoff and erosion measurements with and without grass hedges were collected from different plots.

Separate statistical analyses were performed on the plots with and without corn residue. Initial statistical tests using the Statistical Analysis System (SAS 1988) indicated that runoff and soil loss data, both with and without corn residue, were not normally distributed. Because of the non normality and large variability of the data, a log transform was used. Following the log transform, the data were found to be normally distributed. Analysis of variance was performed on the transformed data collected with corn residue and with corn residue removed to determine differences among experimental treatments (Steel and Torrie 1980). Means were determined by inverse log transformations, and orthogonal contrasts were used to identify treatment effects. A random combination of fertilizer and hedge conditions were considered as treatments and were randomly assigned to subplots. Tillage or no-till conditions were main plots.

Results and Discussion

As overland flow moved downslope into the narrow grass hedges, backwater began to appear above the grass hedges. Backwater formed along the entire plot width because sheet metal borders were located on both sides of the plot. The backwater condition provided a greater opportunity for runoff to infiltrate and a positive hydraulic head in the water at the soil surface, which filled macropores with water and enabled them to be major contributors to the infiltration rate. Dabney et al. (1995) have reported that settling in the backwater upslope from the hedge is the primary mechanism for trapping sediment.

As backwater depth increased, runoff was observed to move through the grass hedge at one or two locations, not uniformly across its entire length. The cross sectional area of the hedge contributing to runoff was usually small. The number, width, and discharge rate of the individual flow channels forming below the hedge appeared to vary substantially between plots. These factors may have contributed to the large variability in runoff and soil loss data reported in Table 1. The importance of maintaining uniform flow into on-farm vegetative filter strips has been described by Dillaha et al. (1989).

Comparison of Treatments With Corn Residue. At the time of the initial run, soil water content, determined on a dry weight basis, was similar on the no-till and tilled plots. For the 0 to 15 cm (0 to 6 in) depth, soil water content varied from 17 to 29% with a mean value of 22%. At the 15 to 30 cm (6 to 12 in) depth, soil water content varied from 22 to 27% with a mean value of 24%.

During the initial run, no runoff was observed on 19 of the 36 treatments with corn residue. When averaged across all plots, 98% of the 64 mm (2.5 in) of rainfall which was applied during the initial run infiltrated. Since runoff and soil loss were minimal during the initial run, the effectiveness of the narrow switchgrass hedges in reducing downslope sediment transport was determined primarily from measurements obtained during the wet run.

Under no-till conditions, residue cover varied from 51 to 94%, with a mean value of 79% (Table 1). Following tillage on the treatments with corn residue, residue cover ranged from 11 to 58% and had a mean value of 34%. Thus, the single disking operation reduced mean residue cover to less than half of its initial value.

Runoff and soil loss have been shown to be substantially impacted by a reduction in residue cover caused by tillage (Laflen et al. 1978; Cogo et al. 1984; Yoo et al. 1987). In this study, tillage induced differences in runoff and soil loss during the wet run on the treatments with corn residue were significant at the 1 and 2% levels, respectively (Table 2).

Analysis of variance was used to compare measurements obtained with the addition of manure versus the control and fertilizer treatments, both with and without a grass hedge (Table 2). In general, the addition of a single application of manure did not substantially impact runoff and soil loss. Runoff and soil loss measurements on the control and fertilizer treatments were also similar.

In contrast, differences in runoff and soil loss during the wet run for the hedge versus no-hedge treatments were significant at the 1 and 3% levels, respectively (Table 2). When measurements for the initial and wet rainfall simulation runs were averaged across the no-till treatments, runoff and soil loss on the plots which contained grass hedges were reduced by 52 and 53%, respectively. For tilled conditions, 22 and 57% less runoff and soil loss were measured on the plots with grass hedges. These results are especially noteworthy since the two simulation events within a 24 hour period represent a storm that would occur less than once every 25 years.

Table 2. Tillage and treatment effects on runoff and soil loss from the initial and wet rainfall simulation runs on the treatments with corn residue; and analysis of variance.

Variable*		Initial Run		Wet Run	
		Runoff (mm)	Soil Loss (Mg ha^{-1})	Runoff (mm)	Soil Loss (Mg ha^{-1})
Tillage					
No-till		0.3	0.02	9.6	0.49
Tilled		2.7	0.30	18.9	1.21
Treatment					
Control Without Grass Hedge		2.2	0.22	19.0	1.23
Control With Grass Hedge		1.3	0.04	10.1	0.42
Fertilizer Without Grass Hedge		2.5	0.39	17.6	1.38
Fertilizer With Grass Hedge		1.1	0.14	14.6	0.78
Manure Without Grass Hedge		1.0	0.08	14.4	0.89
Manure With Grass Hedge		0.9	0.08	9.9	0.41
Analysis of Variance †	**df**	PR > F			
Replication	2	0.19	0.40	0.04	0.36
Tillage	1	0.01	0.02	0.01	0.02
Replication X Tillage	2				
Treatment	5	0.74	0.52	0.09	0.25
Hedge vs. No-Hedge	1	0.30	0.22	0.01	0.03
Manure Without Grass Hedge vs. Control and Fertilizer Without Grass Hedge	1	0.24	0.20	0.12	0.34
Manure With Grass Hedge vs. Control and Fertilizer With Grass Hedge	1	0.80	0.93	0.48	0.65
Control vs. Fertilizer	1	0.85	0.36	0.69	0.48
Tillage X Treatment	5	0.96	0.74	0.90	0.79
CV (%)		7.3	1.4	8.4	3.0

* Runs lasted for a 60 minute duration. Average rainfall intensity was 64 mm hr.

† Analysis of variance was performed on the transformed data (log parameter + 10).

Table 3. Runoff and soil loss from the initial and wet rainfall simulation runs on the treatments where corn residue was removed; and analysis of variance.

Treatment*		Initial Run		Wet Run	
		Runoff (mm)	Soil Loss (Mg ha^{-1})	Runoff (mm)	Soil Loss (Mg ha^{-1})
Without Grass Hedge		30.5	15.31	37.4	14.09
With Grass Hedge		11.5	2.36	28.8	8.48
Analysis of Variance †	**df**	PR > F			
Replication	2	0.75	0.87	0.99	0.89
Treatment	1	0.12	0.09	0.58	0.49
CV (%)		8.8	9.9	10.5	15.2

* Runs lasted for a 60 minute duration. Average rainfall intensity was 64 mm hr.

† Analysis of variance was performed on the transformed data (log parameter + 10).

Comparison of Treatments Where Corn Residue Was Removed. Antecedent soil water content at the 0 to 15 cm (0 to 6 in) depth on the treatments where corn residue was removed, ranged from 19 to 24% with a mean value of 22%. For the 15 to 30 cm (6 to 12 in) depth, soil water content varied from 24 to 27% with a mean value of 25%. Thus, the antecedent soil water conditions with corn residue and where corn residue was removed were similar.

In contrast to the treatments with corn residue, a substantial amount of runoff occurred during the initial run on the plots where corn residue was removed. For the hedge versus no-hedge condition, differences in runoff and soil loss during the initial run were significant at the 12 and 9% levels, respectively (Table 3).

When results from the initial and wet rainfall simulation runs were combined, the grass hedges reduced runoff and soil loss by 41 and 63%, respectively, on the treatments where corn residue was removed. It is apparent from these results that narrow grass hedges should not be the only conservation measure used on a farm. Grass hedges would be best suited for use with other conservation practices such as no-till or reduced-tillage systems which maintain crop residues on the soil surface.

Conservation Benefits Provided by Narrow Grass Hedges. Rainfall intensity and total rainfall amount are primary factors affecting runoff. Figures 2 and 3 were constructed by adding cumulative runoff and soil loss, respectively, from both the initial and wet rainfall events that each had an intensity of approximately 64 mm hr^{-1} (2.5 in hr^{-1}). The data points for the treatments with corn residue are each mean values obtained from the three control plots representing a particular experimental treatment. Minor variations in total water application appeared between experimental treatments due primarily to wind drift.

Figures 2 and 3 are useful in estimating the effects of larger and extended precipitation events on runoff and soil loss. Information contained in these figures can help in understanding long term soil loss records, such as those at Coshocton, Ohio (Edwards and Owens 1991), where a major proportion of the total soil losses

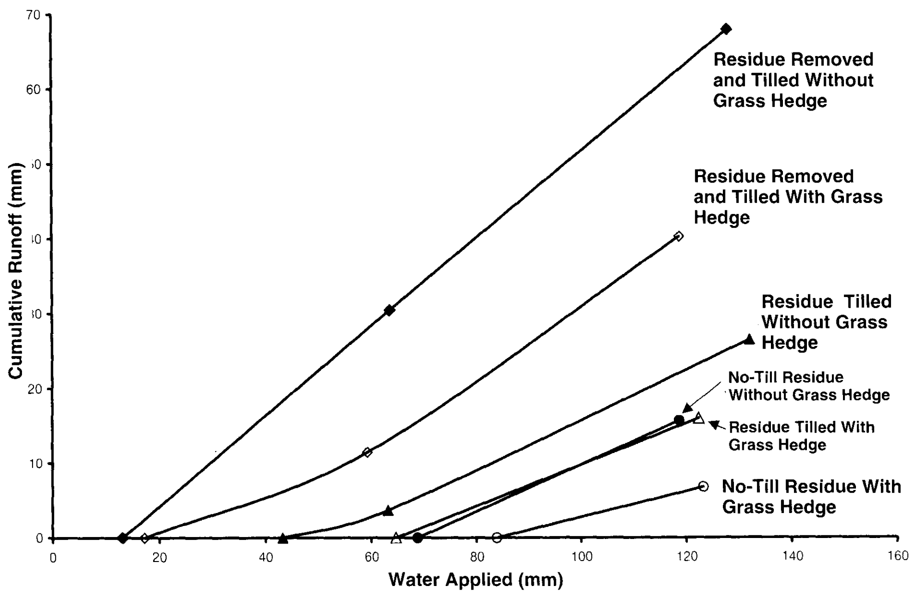

Figure 2. Cumulative Runoff vs. Water Applied for three residue conditions with and without a grass hedge.

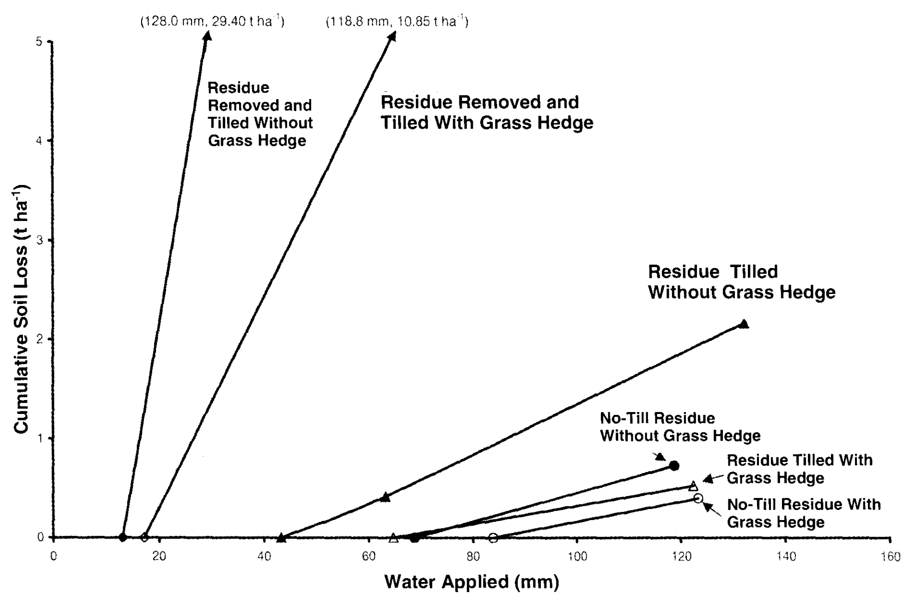

Figure 3. Cumulative Soil Loss vs. Water Applied for three residue conditions with and without a grass hedge.

occurring over several decades has resulted from one or two extreme precipitation events.

It is apparent from Figures 2 and 3 that the grass hedges provided substantial reductions in runoff and soil loss under both tilled and no-till conditions. Maintaining crop residues on the soil surface, no-till farming, and the use of narrow grass hedges almost eliminated runoff from storms expected once in ten years (64 mm hr^{-1} for 1 hr). These same practices, which are so effective in reducing and often eliminating runoff, also cause substantial sediment deposition. Consequently, more of the soil is kept along the hillslope where it belongs and the sediment content of runoff is reduced.

Another benefit resulting from the reduction in runoff is increased availability of water needed for crop growth. While soil water storage is most important in the more arid regions of the nation, lack of available water during the growing season is a common factor limiting crop production throughout the United States.

Conclusions

Simulated rainfall of 64 mm hr^{-1} (2.5 in hr^{-1}) was applied for two hours within a 24 hour period on 3.7 m (12 ft) wide by 10.7 m (35.1 ft) long plots with and without 0.72 m (2.4 ft) wide grass hedges located across the bottom of the plots. The site had been used to grow continuous corn for 33 years, and the grass hedges had been established for six years at the time of testing. The area above the hedges had slope gradients which ranged from 8 to 16% and corn residue under tilled or no-till conditions, or corn residue removed. Even though the grass hedges covered only 7% of the total plot area, they caused substantial reductions in runoff for each of the surface conditions. Total runoff from the plots containing grass hedges and having corn residue removed, corn residue under tilled conditions, or corn residue under no-till conditions averaged 40.3, 18.9, and 6.4 mm (1.59, 0.74, and 0.25 in), respectively, as compared to 67.9, 24.3, and 13.4 mm (2.67, 0.96, and 0.53 in), respectively, for similar plots without grass hedges. The appearance of backwater above the grass hedges resulted in substantial sedimentation. Soil losses averaged 18.84, 0.91, and 0.32 Mg ha^{-1} (8.4, 0.41, and 0.14 t ac^{-1}) on the plots containing grass hedges and having corn residue removed, corn residue under tilled conditions, or corn residue under no-till conditions, respectively, as compared to 29.40, 2.10, and 0.69 Mg ha^{-1} (13.1, 0.94 and 0.31 t ac^{-1}), respectively, for comparable plots without grass hedges. Narrow grass hedges are best suited for use in conjunction with other conservation measures such as no-till or reduced-till farming systems.

Acknowledgements

This article is a contribution from USDA-ARS in cooperation with the Agricultural Research Division, University of Nebraska, Lincoln, and is published as Journal Series No. 12280. The authors gratefully acknowledge W.D. Kemper, USDA-ARS (retired), for his scientific and leadership contributions involving the use of grass hedges for wind and water erosion control, and his assistance in the preparation of this and the companion manuscript.

REFERENCES CITED

Bingham, S.C., P.W. Westerman, and M.R. Overcash. 1980. Effect of grass buffer zone length in reducing the pollution from land application areas. Transactions of the American Society of Agricultural Engineers 23 (2):330-335.

Cogo, N.P., W.C. Moldenhauer, and G.R. Foster. 1984. Soil loss reductions from conservation tillage practices. Soil Science Society of America Journal 48 (2):368-373.

Coyne, M.S., R.A. Gilfillen, R.W. Rhodes, and R.L. Blevins. 1995. Soil and fecal coliform trapping by grass filter strips during simulated rain. Journal of Soil and Water Conservation 50 (4):405-408.

Dabney, S.M., L.D. Meyer, W.C. Harmon, C.V. Alonso, and G.R. Foster. 1995. Depositional patterns of sediment trapped by grass hedges. Transactions of the American Society of Agricultural Engineers 38 (6):1719-1729.

Daniels, R.B., and G.W. Gilliam. 1996. Sediment and chemical load reduction by grass and riparian filters. Soil Science Society of Amercia Journal 60 (1):246-251.

Dewald, C.L., J. Henry, S. Bruckerhoff, J. Ritchie, S. Dabney, D. Shepherd, J. Douglas, and D. Wolf. 1996. Guidelines for establishing warm season grass hedges for erosion control. Journal of Soil and Water Conservation 51 (1):16-20.

Dillaha, T.A., R.B. Reneau, S. Mostaghimi, and D. Lee. 1989. Vegetative filter strips for agricultural nonpoint source pollution control. Transactions of the American Society of Agricultural Engineers 32 (2):513-519.

Edwards, W.M., and L.B. Owens. 1991. Large storm effects on total soil erosion. Journal of Soil and Water Conservation 46 (1):75-77.

Eghball, B., and J.F. Power. 1999. Phosphorus and nitrogen-based manure and compost application: Corn production and soil phosphorus. Soil Science Society of America Journal 63:July-August.

Eghball, B., J.E. Gilley, L.A. Kramer, and T.B. Moorman, 2000. Narrow grass hedge effects on phosphorus and nitrogen in runoff following manure and fertilizer application. Journal of Soil and Water Conservation: this issue.

Gilley, J.E., and B. Eghball. 1998. Runoff and erosion following field application of beef cattle manure and compost. Transactions of the American Society of Agricultural Engineers 41 (5):1289-1294.

Hershfield, D.M. 1961. Rainfall frequency atlas of the United States. Weather Bureau Technical Paper No. 40. Washington, D.C.: U.S. GPO.

Kemper, D., S. Dabney, L. Kramer, D. Dominick, and T. Keep. 1992. Hedging against erosion. Journal of Soil and Water Conservation 47 (4):284-288.

Laflen, J.M., J.L. Baker, R.O. Harwig, W.F. Buchele, and H.P. Johnson. 1978. Soil and water loss from conservation tillage systems. Transactions of the American Society of Agricultural Engineers 21 (5):881-885.

Magette, W.L., R.B. Brinsfield, R.E. Palmer, and J.D. Wood. 1989. Nutrient and sediment removal by vegetated filter strips. Transactions of the American Society of Agricultural Engineers 32 (2):663-667.

Mannering, J.V., and L.D. Meyer. 1963. The effects of various rates of surface mulch on infiltration and erosion. Soil Science Society of American Proceedings 27 (1):84-86.

Meyer, L.D. 1960. Use of the rainulator for runoff plot research. Soil Science Society of American Proceedings 24:319-322.

Meyer, L.D., S.M. Dabney, and W.C. Harmon. 1995. Sediment-trapping effectiveness of stiff-grass hedges. Transactions of the American Society of Agricultural Engineers 38 (3):809-815.

Rafaelle, J.B., K.C. McGregor, G.R. Foster, and R.F. Cullam. 1997. Effect of narrow grass strips on conservation reserve land converted to cropland. Transactions of the American Society of Agricultural Engineers 40 (6):1581-1587.

SAS Institute. 1988. SAS/STAT user's guide, 6.09 ed. SAS Inst., Cary, NC.

Robinson, C.A., M. Ghaffarzadeh, and R.M. Cruse. 1996. Vegetative filter strip effects on sediment concentration in cropland runoff. Journal of Soil and Water Conservation 50 (3):227-230.

Steel, R.G.D., and J.H. Torrie. 1980. Principles and procedures of statistics: A biometrical approach. New York: McGraw-Hill Book Company.

Swanson, N.P. 1965. Rotating boom rainfall simulator. Transactions of the American Society of Agricultural Engineers 8 (1):71-72.

Yoo, K.H., J.T. Touchton, and R.H. Walker. 1987. Effect of tillage on surface runoff and soil loss from cotton. Transactions of the American Society of Agricultural Engineers 30 (1):166-168.