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Kingsville, TX

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GRASS HEDGES FOR GULLY EROSION CONTROL

INTRODUCTION

Grass hedges are narrow strips (1-3 feet wide) of stiff, erect, densely growing grasses planted across the slope perpendicular to the dominant slope. These hedges function to slow water runoff, trap sediment and prevent gully development (Dabney et al. 1993). The hedges inhibit the flow of water because of their dense concentration of thick stems, thus slowing and ponding water and causing sediment to deposit in back of them (Meyers et al. 1994). Over time these deposits can develop into benched terraces (Aase and Pikul, 1995). These hedges function to diffuse and spread the water runoff so that it slowly flows through them without erosion. Grass hedges are resilient to failure because water passes over a broad area secured with perennial root reinforcement.

The objective of this study was to establish a series of grass hedge barriers and assess their ability to control gully erosion. Support and funding was provided by the Austin County Soil and Water Conservation District, the Texas State Soil and Water Conservation Board, and the United States Environmental Protection Agency.

MATERIAL AND METHODS

The study was conducted on a farm near Kenney, Tex., in Austin County. The treatment field is a severely overgrazed pasture with a 700 feet long gully with a 6 1/2 foot head-cut. The soils of the field are a Frelsburg clay with a 1 to 8 percent slope and a Latium clay with a 2 to 12 percent slope. In September of 1996 we crudely shaped the gully head to a 5:1 slope.

A baseline elevational survey was conducted in August, 1996, on 14 grass hedge lines. On September 16, 1997, vetiver grass was planted. The grass hedges range in length from 25 feet to 100 feet in length. The distance between the grass hedges varies from 13 feet to 74 feet with a vertical index from 1.7 feet to 2.5 feet. Slopes range from 2.8 percent to 16 percent.

Vetiver was planted as a single row across the basin depth, which ranged from 1.4 feet to 5.0 feet in height. Bareroot vetiver clumps of 4 stems were planted end-to-end across the basin 1/2 depth. The outside 1/2 depth was planted with 4 stem clumps at a three-inch interval. Vetiver was 9” tall with 4” roots. A trencher was used to produce a 6-inch wide trench. A 13-13-13 fertilizer was sprinkled in the trench at approximately an 80#/acre rate of actual nitrogen. Plants were placed in the trench and then backfilled. Straw bundles from 5 inches to 9 inches thick were placed on the downstream side across the 1/2 basin depth locations to prevent dislodging of the plants. No water was applied.

A second elevational survey of the site was performed on September, 16, 1996, right after planting, and another survey was conducted on July 30, 1997. The survey consisted of measurements at the ends of the grass hedges and at the 1/2 depth locations on either side of the grass hedges and in the middle. Measurements were also taken at 4 feet upstream, 4 feet downstream, and 20 feet upstream. A vegetational survey was conducted on May 12, 1997, and on September 18, 1997. Measurements were taken on percent survival, stem density (numbers per square foot), height (centimeters), base width (centimeters), and gaps between plants (number of spaces greater than 15 centimeters apart). Velocities (feet per second-ft/sec) and volume of surface runoff (cubic feet per second-cfs) were determined using the Natural Resources Conservation Service WWCALC engineering software program.

RESULTS AND DISCUSSION

HEDGE BARRIER STABILITY

Immediately after planting on September 18, 1996, an estimated ten year rainfall event (3.5” in 6 hrs) occurred that washed out several of the grass hedges (Table 1). Severe runoff broke the straw bundles and dislodged the plants. At high velocities, straw bundles staked through the middle will not stay secured. They must be staked and woven down with baling string. We resecured all the bundles on September 19, 1996, and they have remained secure throughout the study.

Grass hedge barriers 4,5,6,7, and 10 developed plunge pools because of the high velocity of the surface runoff (Table 2). This forced us to add concrete cylinders at these locations. We were afraid that the deep plunge pools would threaten the stability of the entire gully treatment.

Grass hedges 8 and 14 had velocities greater than grass hedges 4 and 7 which failed (Table 2). The difference between these hedges and the ones that failed were the length and steepness of upstream conditions and the narrowness of the channel downstream of the grass hedge.

Grass hedge 3 stayed stable with a hedge length of 30 feet and a slope greater than 10% for 60 feet upstream. Grass hedge 4 failed with an average slope greater than

10% for 80 feet upstream. The channel width for hedge number 4 was only 20 feet and narrowed to 15 feet directly below the barrier. The velocity as it approached hedge 5 was 7.7 feet per second (ft./sec.). This velocity on the bare soil below hedge 4 is what caused the plunge pool which required remedial treatment.

Grass hedge number 10 failed with a slope of 9% for 30 feet upstream. Grass hedge 10 had a channel width of only 15 feet that narrowed to five feet directly below the barrier. Again the velocity below the hedge was well over 7 ft./sec. and caused the plunge pool that nearly undermined the hedge.

Grass hedge 8 stayed stable despite a velocity of 6 ft./sec. and a channel width that was 15 feet both at the hedge and downstream of the hedge. The slope averaged less than 6% for over 80 feet upstream and the downstream hedge had a velocity of only 5.2 ft./sec. Grass hedge 14 also stayed stable with a velocity of approximately 6 ft./sec. The slope was roughly 7.5% and the channel width was 20 feet. Thirty feet upstream the slope was less than 4% and the velocity was less than 4 ft./sec. Downstream the slope flattened out and the velocity was less than 6 ft./sec.

It appears that grass hedges will be stable when constructed appropriately for velocities at 4 ft./sec. and volume less than 50 cubic ft./sec. Grass hedges will probably be stable at higher velocities up to 6 ft./sec. when the channel width is maintained at a consistent width at the hedge and downstream of the hedge. Optimum channel width for the grass hedges at our site was between twenty and thirty feet wide. Grass hedge length should be based on the width determined by the grass waterway calculation.

The limiting factor on velocity should be the soil velocity relationship. “Permissible velocities for channels lined with vegetation” and “Permissible velocity for vegetated spillways” in the SCS-TP-61 handbook provides a useful guide for this relationship (Table 3) and (Table 4). At our site, which had erosion resistant soils and slopes between 5-10%, the suggested permissible velocity would be 3.5 ft/sec. This is the permissible velocity suggested for native grass mixtures, and the suggested value for the bare soil, native plant composition that existed at our test site. At this time, we would not recommend exceeding the velocities established for specified seed mixtures for newly constructed sites. As a repair or secondary treatment for existing vegetated sites, we probably can use grass hedges at increased velocities of 1 to 2 ft./sec. above these levels.

VETIVER GRASS PERFORMANCE

Spot planting of vetiver grass was necessary after the September 18, 1996, rainfall event and again in April of 1997.

The results of the vegetation survey conducted on May 12, 1997, are presented in Table 5. Total survival of vetiver for the winter averaged 61 % across all the hedges. Numerous gaps between plants exceeded the 15 centimeter/6 inches threshold required for a successful hedge planting (Technote 1996). The results of the vegetation survey conducted on September 16, 1997, revealed a summer survival rate of 93% (Table 6). However, there were still spots where the gaps exceeded the 15cm threshold.

Vetiver grass performed better when planted in the spring versus the fall at this site. Competition from cool season vegetation and freezing temperatures had a detrimental impact on vetiver survival. Vetiver appears to prefer planting in the spring at a time when it is starting its period of rapid growth.

Vetiver mortality at some hedges was located at the lowest point of the barriers, indicating that high velocities may have been a factor. In the summer, most of the vetiver mortality was located at the outside edges where reduced soil moisture may have been encountered. Any growth of vetiver is remarkable at this site since it is a crudely shaped gully with very poor, hard clay subsoil. It is recommended that two rows of transplants be used to minimize gaps, reduce replanting, and ensure functionality of the grass hedge.

SEDIMENT MOVEMENT

Figure 1 shows sediment gains or losses at selected grass hedges during our elevational surveys. Grass hedge number 3 accumulated sediment from 1-2 inches across the basin except for the eastern end. Sediment accumulated despite a spotty vegetational stand. Most of the sediment trapped is probably attributable to the straw bundles. The straw bundles weather down to a height of approximately 2-3 inches which is what was accumulated at this hedge.

Grass hedge 11 had a variable elevational pattern. Sediment accumulated at about the same depth as hedge number 3 in the concentrated flow area despite a more solid grass barrier. However, the eastern end of this hedge lost over ten inches of soil due to a very steep side slope.

Grass hedge 7 accumulated from 2-3 inches across the hedge width. Hedge number 7 had a good solid grass stand.

Grass hedge 4 had a variable elevational pattern similar to barrier 11. There were vegetational gaps at this hedge at the outer edges. Where the hedge was solid, it accumulated over 6 inches of soil. The eight inch loss of soil came mostly from down cutting from steep side slopes that followed parallel to the hedge.

Where grass hedges have steep, bare side slopes, soil may be redistributed across the basin. It appears that where a good solid grass hedge is established soil will accumulate. However, further monitoring is necessary to verify this conclusion.

CONCLUSION

Grass hedges can help stabilize gullies when appropriately designed and constructed. Gullies should be surveyed, designed, and shaped similar to grass waterways. Velocities and volumes must be carefully calculated. Grass hedge barriers can add erosion control effectiveness on high velocity critical sites when combined with grass waterways by slowing and dispersing surface water runoff to prevent down cutting and channelization.

TABLE 1

Monthly precipitation (inches) for the closest weather station (Bellville) to the study site.

MONTH	YEAR	INCHES
Sept.	1996	9.83
Oct.	1996	1.67
Nov.	1996	2.86
Dec.	1996	2.65
Jan.	1997	4.81
Feb.	1997	6.10
Mar	1997	5.95
Apr	1997	5.03
May	1997	6.24
Jun	1997	4.85
Jul	1997	1.69
Aug.	1997	3.22
Sep	1997	3.57

TABLE 2

Velocity and Discharge of Surface Runoff at the Grass Hedges in Kenney, Texas.

GRASS HEDGE	DISCHARGE (cfs)	VELOCITY (ft/sec)	PLUNGE POOL (ft)
1	27	2.7	
2	27	2.5	
3	27	3.8	
4	35	4.9	2
5	40	7.7	1.7
6	40	9.6	2.1
7	40	5.4	2.0
8	47	6.1	
9	47	5.2	
10	47	7.0	1.8
11	47	4.5	
12	52	3.5	
13	52	3.5	
14	52	6.0	

TABLE 3:

Permissible velocities for channels lined with vegetation[1]
The values apply to average, uniform stands of each type of cover.

COVER	SLOPE RANGE[2]	PERMISSIBLE VELOCITY EROSION RESISTANT SOILS	EASILY ERODED SOILS
	Percent	Ft. per. sec.	Ft. per. sec.
Bermudagrass }......................	0-5	8	6
	5-10	7	5
	over 10	6	4
Buffalograss Kentucky bluegrass }.................. Smooth brome Blue grama	0-5	7	5
	5-10	6	4
	over 10	5	3
Grass mixture }..................	[2] 0-5	5	4
	5-10	4	3
Lespedeza sericea Weeping lovegrass Yellow bluestem Kudzu }.................. Alfalfa Crabgrass	[3] 0-5	3.5	2.5
Common lespedeza[4] }................... Sudangrass[2]	[5] 0-5	3.5	2.5

[1] Use velocities exceeding 5 feet per second only where good covers and proper maintenance can be obtained.
[2] Do not use on slopes steeper than 10 percent, except for side slopes in a combination channel.
[3] Do not use on slopes steeper than 5 percent, except for side slopes in a combination channel.
[4] Annuals--used on mild slopes or as temporary protection until permanent covers are established.
[5] Use on slopes steeper than 5 percent is not recommended.

TABLE 4:

Permissible velocity for vegetated spillways[1]

Vegetation	Permissible velocity[2] Erosion-resistant soils[3], Slope of exit channel		Permissible velocity[2] Easily eroded soils[4], Slope of exit channel	
	pct 0-5	pct 5-10	pct 0-5	pct 5-10
	ft/s	ft/s	ft/s	ft/s
Bermudagrass, Bahiagrass	8	7	6	5
Buffalograss, Kentucky bluegrass, Smooth brome, Tall fescue, Reed canarygrass	7	6	5	4
Sod-forming grass -legume mixtures	5	4	4	3
Lespedeza sericea, Weeping lovegrass, Yellow bluestem, Native grass mixtures	3.5	3.5	2.5	2.5

[1]SCS-TP-61

[2]Increase values 10 percent when the anticipated average use if the spillway is not more frequent than once in 5 years, or 25 percent when the anticipated average use is not more frequent than once in 10 years.

[3]Those with a higher clay content and higher plasticity. Typical soil textures are silty clay, sandy clay, and clay.

[4]Those with a high content of fine sand or silt and lower plasticity, or non-plastic. Typical soil textures are fine sand, silt, sandy loam, and silty loam.

TABLE 5:

May 1997, Vetiver Grass Results from September, 1996, Planting at the Study Site in Kenney, TX.

BARRIER	PLANT SPECIES	PERCENT SURVIVAL	STEM DENSITY (#/SQ.FT.)	HEIGHT (CM)	BASE WIDTH (CM)	GAPS* (#>15CM)	LARGEST GAP (CM)
SITE A							
1	VETIVER GRASS	50	5	64	2	12	74
2	VETIVER GRASS	67	3	53	1	24	103
3	VETIVER GRASS	60	5	63	2	17	115
4	VETIVER GRASS	22	3	64	2	9	72
5	VETIVER GRASS	58	4	51	2	8	136
6	VETIVER GRASS	39	4	63	2	7	91
7	VETIVER GRASS	58	6	54	2	3	305
8	VETIVER GRASS	50	3	47	1	9	89
9	VETIVER GRASS	58	8	48	1	7	198
10	VETIVER GRASS	80	7	62	1	5	137
11	VETIVER GRASS	93	9	61	2	1	19
12	VETIVER GRASS	70	6	52	1	5	33
13	VETIVER GRASS	71	5	54	2	9	61
14	VETIVER GRASS	93	8	56	2	2	19

TABLE 6:

September, 1997, Vetiver Grass Results from September, 1996, Planting at the Study Site in Kenney, TX.

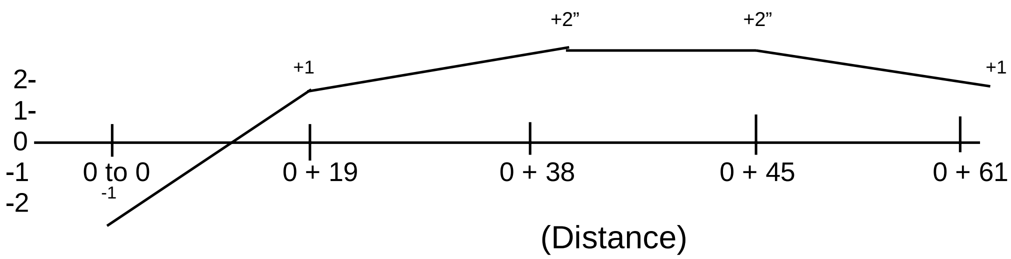
BARRIER	PLANT SPECIES	PERCENT SURVIVAL	STEM DENSITY (#/SQ.FT.)	HEIGHT (CM)	BASE WIDTH (CM)	GAPS* (#>15cm)	LARGEST GAP (CM)
SITE A							
1	VETIVER GRASS	89	0	7.0	4.3	6	25
2	VETIVER GRASS	89	3	79	8	6	91*
3	VETIVER GRASS	100	6	89	8	4	91
4	VETIVER GRASS	83	8	84	8	2	144*
5	VETIVER GRASS	93	8	87	8	2	37*
6	VETIVER GRASS	100	12	91+	10	2	23
7	VETIVER GRASS	80	3	82	7	0	
8	VETIVER GRASS	100	3	91+	7	3	30
9	VETIVER GRASS	100	15	91+	11	2	47
10	VETIVER GRASS	100	9	91+	8	6	49
11	VETIVER GRASS	92	4	87	7	0	-
12	VETIVER GRASS	100	3	89	6	1	27
13	VETIVER GRASS	86	2	84	7	0	
14	VETIVER GRASS	86	1	86	8	0	-

* Gaps were outside the concentrated flow area.

FIGURE 1

Sediment Gains or Losses (in inches) at Selected Grass Hedges at the Study Site in Kenney, TX. in September, 1997

TERRACE 3



TERRACE 4

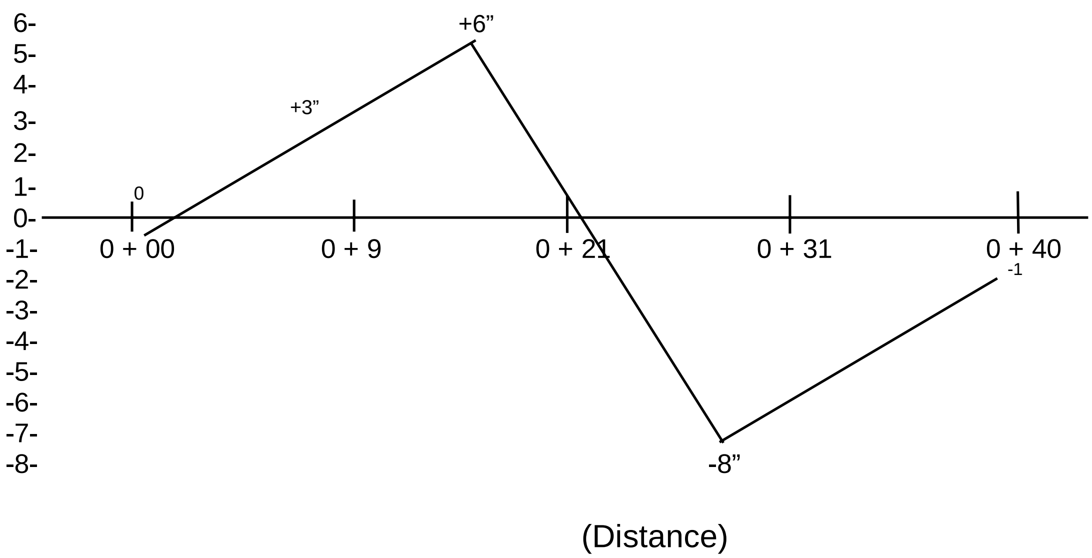
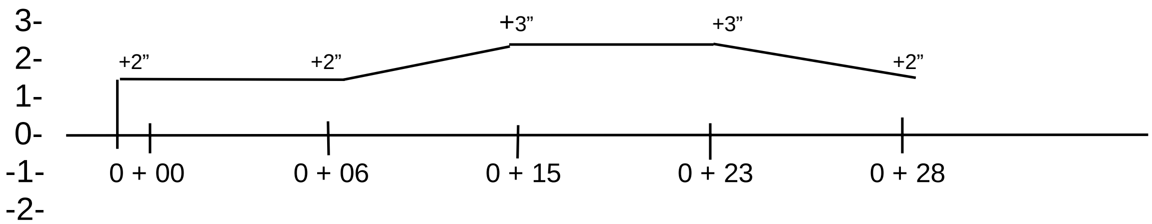


FIGURE 1 CONTINUED

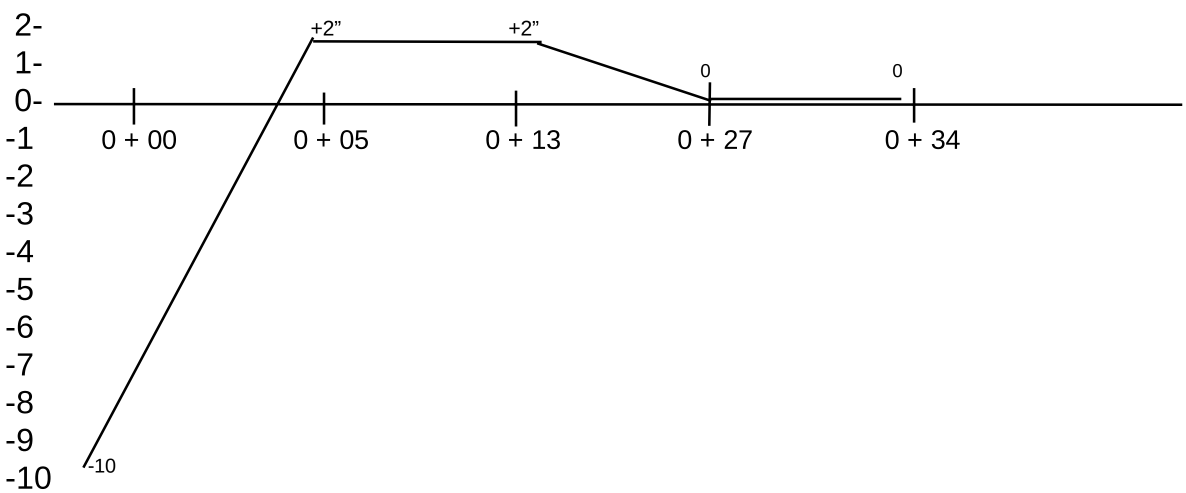
Sediment Gains or Losses (in inches) at Selected Grass Hedges at the Study Site in Kenney, TX. in September, 1997

TERRACE 7



(Distance)

TERRACE 11



(Distance)

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