EROSION CONTROL IN COTTON PRODUCTION THROUGH THE USE OF ULTRA NARROW ROW

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Abstract. Grass hedges and no-till cropping systems reduced soil losses on standard erosion plots in ultra narrow-row (20 cm) cotton during a four-year study (1999-2002). No-till cotton with grass hedges, no-till cotton without grass hedges, conventional-till cotton with grass hedges, and conventional-till cotton without grass hedges produced four-year average annual soil losses of 1.8, 2.9, 4.0, and 30.8 t/ha, respectively, and produced four-year average runoff amounts of 226, 364, 338, and 738 mm, respectively. The ratio of annual soil loss with grass hedges to without hedges averaged 0.62 for no-till. The ratio of annual soil loss with grass hedges to without hedges was 0.13 for conventional-till. Averaged over all plots (with and without grass hedges), no-till plots reduced soil loss from conventional-till plots by 86%. No-till plots without grass hedges had 90% less soil loss than conventional-till plots without grass hedges. Grass hedges effectively reduced soil loss on erosion plots with similar cropping practices as compared to plots without hedges. Other studies of contoured grass hedges on field-sized areas are being conducted to determine their applicability on larger areas with greater concentrations of runoff.

INTRODUCTION

Grass hedges are narrow strips of stiff, erect dense grass planted close to the contour that can withstand concentrated flows that would bend and overtop finer vegetation (Dunn and Dabney, 1996). Dabney et al. (1995, 1996) concluded that stiff-grass hedges planted across concentrated flow zones retard and spread out surface runoff, cause deposition of eroded sediment, and control ephemeral gully development.

McGregor et al. (1999) published runoff and soil loss data for no-till and conventional-till cotton plots (with and without stiff-grass hedges) for standard row widths (100 cm) at Holly Springs, MS. These were the same plots as used in this ultra narrow-row (20 cm) study. Hedges were established in the spring of 1991. Original standard-row width treatments consisted of no-till cotton with grass hedges, no-till cotton without grass hedges, conventional-till cotton with grass hedges, conventional-till cotton without grass hedges, and no-till cotton without grass hedges but with a winter wheat cover crop. Average annual crop year soil losses (1992-1994) were highest for conventional-till cotton without grass hedges followed by conventional-till cotton with hedges, no-till cotton without hedges, no-till cotton with hedges, and no-till cotton with winter wheat cover. No-till cropping practices effectively reduced soil losses as compared to conventional-till. Averaged over all plots (with and without grass hedges, but not including winter cover plots), no-till plots reduced soil loss from conventional-till plots by 88%. No-till plots without grass hedges had 57% less soil loss than conventional-till plots with grass hedges.

McGregor and Dabney (1993) reported reduced soil losses during the first growing season (1991) of establishment of grass hedges on these cotton plots, even though completely consolidated hedges were not produced. During the 1991 cotton growing season, soil loss on conventional-till plots with hedges was 31.4 t/ha as compared to 56.0 t/ha for conventional-till plots without hedges. During the same period, soil loss from no-till cotton with hedges averaged 1.8 t/ha as compared to 3.1 t/ha for no-till plots without hedges.

The USDA-ARS National Sedimentation Laboratory conducts other field studies on larger plots and watersheds to evaluate the upper limits of concentrated flow for grass hedges and to evaluate their potential for use in conservation tillage systems in a manner similar to terraces. The conservation objective is to cause sediment deposition above the hedges, disperse concentrated flow, and reduce ephemeral gully development

This paper reports the runoff and soil losses for ultra narrow-row cotton (UNRC) plots during 1999-2002 and evaluates the erosion-control effectiveness of the stiff-grass hedges. Row ridges were not used in any of the ultra narrow-row treatments. Soil loss ratios are estimated for use in the revised universal soil loss equation (RUSLE) for ultra narrow-row cotton planted without row ridges.

Objectives of the study were to: (1) compare runoff from no-till and conventional-till, non-ridged ultra narrow-row, cotton plots with and without stiff-grass hedges; (2) evaluate the effectiveness of fully developed stiff-grass hedges for reducing erosion for cotton; and (3) estimate soil loss ratios for non-ridged ultra narrow-row cotton for use in soil loss prediction.

PROCEDURE

The study was conducted at the North Mississippi Branch of the Mississippi Agricultural and Forestry Experiment Station, Holly Springs, MS. Erosion plots were 4 m wide and 22.1 m long on 5% slopes. Plots were equipped with FW-1 water level recorders, H-flumes, and N-1 Coshocton wheel sampling devices. Soils on the plots were predominantly Providence silt loam (Typic Fragiudalfs).

Stiff grass (*Miscanthus sinesis*) plants that would develop into hedges were transplanted about 0.5 m up slope from the lower ends of standard erosion plots on March 27, 1991 (McGregor and Dabney, 1993). The grass hedge on each plot was a mixture of three accessions (designated 130, 129 and 128) of *Miscanthus sinesis*. Individual plants were about 0.2 m apart. The hedges were transplanted about a month before the initiation of research across four rows of standard row width (100 cm) in 1991. Cotton was planted in 5% sloping rows running perpendicular to the grass hedges on May 3, May 11, May 15, and May 21 and was harvested on October 8, October 13, October 26, and October 24 in 1999, 2000, 2001, and 2002, respectively. UNRC (*Gossypium hirsutum*) treatments included both no-till and conventional-till cotton with and without grass hedges. No-till in this study refers to planting cotton in plots with no tillage operations and only a chemical burndown for weed control. Conventional-till in this study refers to the tillage sequence of two overland passes with a rototiller. Planting on all plots was done with a Marliss no-till drill planter. Cotton was planted on flat beds. Grasses and weeds were controlled with chemicals. Fertilizer and lime additions were based on experiment station recommendations. As part of a related poultry litter efficiency study, nitrogen was applied using an annual application of 3.6 t/ha poultry litter.

In June of each year, all hedges were clipped to a height of 0.5 m. The hedges were clipped using an electric hedge trimmer and hand shears. The lengths of hedge trimmings were about 50 to 80 mm. All grass clippings and cut stems were removed from the plots. In August, the hedges were trimmed again after they had grown to heights averaging from 0.9 to 1.4 m. All clippings were removed from the plots and discarded. All clippings were removed from the plots so the trapping efficiency of the completely developed hedges could be determined.

RESULTS

<u>Grass Hedge Growth Characteristics:</u> Hedges grew well during the first summer after being transplanted into the plots in the spring of 1991. But there were gaps in the hedges about 0.08 m wide at the end of that first growing season (McGregor and Dabney, 1993). Throughout the 1992-1994 study period grass hedges on no-till and conventional-till plots developed in the same manner and with similar characteristics (McGregor *et al.*, 1999). By the end of the 1994 crop year, grass hedges averaged 531 green stems per meter square, 975 dead stems per meter square, and had a base width of 0.6 m. The hedges were well developed by the 1999-2002 study period.

<u>Rainfall, Rainfall Erosion Index, and Runoff:</u> The 4-year average monthly rainfall amounts (Table 1) were fairly evenly distributed throughout the year, except that slightly lower amounts occurred in the summer months. The 4-year average rainfall for the 1999-2002 crop years (May through April) was 1321 mm, similar to the 30-year normal rainfall of 1372 mm for North Central Mississippi (McGregor *et al.*, 1987) and similar to the 1386 mm of rainfall during the earlier 1992-1994 standard row-width cotton study.

The rainfall erosion index, EI, for a storm is a function of the product of storm kinetic energy and the maximum storm 30-minute rainfall intensity. The annual EI used in RUSLE is the expected sum of EI for all storms (McGregor *et al.*, 1995).

The four-year average EI of 7104 MJ•mm•$(\text{ha}\bullet\text{h})^{-1}$ was 30% higher than the long-term expected EI used in RUSLE for Holly Springs (Renard *et al.*, 1997). The 3-year average of 7804 MJ•mm•$(\text{ha}\bullet\text{h})^{-1}$ during the 1992-1994 study was 43% higher than the long-term expected EI.

Table 1 Four-year average rainfall, erosion index, and runoff by months during the1999 thru 2002 crop years for UNRC.

MONTH	RAIN (mm)	EROSION INDEX (MJ mm (ha h)$^{-1}$)	RUNOFF NT-G† (mm)	NT WOG† (mm)	CT-G† (mm)	CT WOG† (mm)
M	117	495	21	17	34	58
J	100	588	24	24	28	45
J	65	880	9	10	14	25
A	72	506	6	7	13	28
S	77	401	9	7	13	37
O	135	1184	30	41	39	70
N	156	736	44	36	46	70
D	146	623	33	28	32	65
J	87	226	16	11	12	25
F	139	491	33	28	46	75
M	123	206	23	21	33	49
A	104	768	21	17	43	42
Crop year	**1321**	**7104**	**269**	**247**	**353**	**589**

† NT = no-till, CT = conventional-till, G = with grass, and WOG = without grass
Note: During the 19 year period (1982-2000 calendar years), EI at Holly Springs was 91.5% of that at Goodwin Creek Watershed, so values were estimated using this result.

Hedges reduced average annual runoff on conventional-till cotton plots by 40%, but runoff from no-till plots with hedges was 9% higher than from no-till plots without hedges (Table 1). However, the runoff from all no-till plots (with and without hedges) was 45% less than runoff from all conventional-till plots. Average annual runoff was highest (Table 1) for conventional-till cotton without grass hedges followed by conventional-till cotton with hedges, no-till cotton with hedges, and no-till cotton without hedges. The four-year average runoff amounts were 269, 247, 353, and 589 mm for no-till with hedges, no-till without hedges, conventional-till with hedges, and conventional-till without hedges, respectively. The four-year average monthly runoff amounts were lowest in January, July, August, and September for all plots.

Generally, runoff differences from no-till plots with and without hedges were small. The four-year average monthly runoff differences for these plots exceeded 5 mm only during October and November (11 and 8 mm, respectively). Average monthly runoff differences for conventional-till plots exceeded 15 mm in all but four months.

Soil Loss: Hedges reduced average annual soil loss on conventional-till cotton plots by 87% and on no-till plots by 37% during 1999-2002 crop years for UNRC as compared to 76% and 58%, respectively, during the 1992-1994 crop years for standard-row cotton (SRC). Average annual soil losses were highest (Table 2) for conventional-till cotton without grass hedges followed by conventional-till cotton with hedges, no-till cotton without hedges, and no-till cotton with hedges. The average soil losses for UNRC were 1.8, 2.9, 4.0, and 30.8 t/ha as compared to 2.2, 5.2, 12.3, and 48.5 t/ha for SRC (1992-1994) for no-till with grass hedges, no-till without hedges, conventional-till with hedges, and conventional-till without hedges, respectively. The higher soil losses during the standard-row study can be partly attributed to significantly higher erosion index although the rainfall was only slightly higher.

No-till cotton plots with and without grass hedges adequately controlled annual soil losses to less than the tolerance value of 7 t/ha whereas the conventional-till cotton plots did not for standard row cotton years. But for the UNRC, the conventional-till plots with hedges as well as the no-till plots with and without hedges controlled annual soil losses to less than the tolerance value of 7 t/ha.

About 16% and 15% of the annual rainfall and annual erosion index for UNRC occurred during the combined months of May and June, during the early growth stages. But about 56% and 57% of the annual soil loss from conventional-till plots with hedges and conventional-till plots without hedges occurred during May and June. Soil loss during May and June for the conventional-till plots with hedges averaged only 2.2 t/ha as compared to 17.6 t/ha for conventional-till plots without hedges.

Table 2 Four-year average soil losses by months during the UNRC crop years.

MONTH	RAIN	SOIL LOSS NT-G†	NT WOG†	CT-G†	CT WOG†
	(mm)	(t/ha)	(t/ha)	(t/ha)	(t/ha)
M	117	0.47	0.35	1.13	8.24
J	100	0.37	1.02	1.09	9.32
J	65	0.04	0.17	0.24	3.30
A	72	0.05	0.08	0.12	1.52
S	77	0.02	0.03	0.06	0.49
O	135	0.17	0.27	0.15	1.26
N	156	0.20	0.28	0.17	1.33
D	146	0.17	0.21	0.37	1.22
J	87	0.10	0.11	0.11	0.72
F	139	0.13	0.13	0.28	1.60
M	123	0.05	0.11	0.08	0.62
A	104	0.08	0.16	0.19	1.14
Crop year	**1321**	**1.85**	**2.92**	**3.99**	**30.76**

† NT = no-till, CT = conventional-till, G = with grass, and WOG = without grass hedge

The standard-row study again illustrated the effectiveness of no-till cropping practices in reducing soil losses as compared to conventional-till. Averaged over all plots (with and without grass hedges), no-till plots reduced soil loss from conventional-till plots by 86%. Averaged over all plots, no-till plots reduced soil loss from conventional-till plots by 88% during the earlier 1992-1994 study.

<u>Ratios of Soil Loss With and Without Grass Hedges:</u> The effect of grass hedges in reducing soil loss was determined by dividing the average soil loss of no-till cotton plots with hedges by the average soil loss of no-till cotton plots without hedges. The annual ratio of soil loss for no-till UNRC plots with grass hedges to those without hedges averaged 0.62. The annual ratio of soil loss for conventional-till plots with grass hedges to without hedges was 0.13.

An erosion control practice factor could be used in RUSLE to give some credit for grass hedges. McGregor *et al.* (1999) reported that the ratio of soil loss from plots with grass hedges to soil loss from plots without grass hedges would reflect 100% credit for soil loss trapped above the hedges. McGregor *et al.* (1999) observed that a higher value may need to be used so that credit for soil trapped immediately above hedges will not be considered applied over the entire plot area.

<u>C-Factor Estimates:</u> The cropping and management C-factor used in USLE is defined as the ratio of soil loss from land cropped under specified conditions to the corresponding loss from tilled continuous fallow land (Wischmeier and Smith, 1978). The ratio calculated for a crop stage is referred to as a soil loss ratio (SLR). Mutchler *et al.* 1985 reported that SLR values for the erosion plots at Holly Springs can be computed with the following equation:

SLR=33.95(Measured Soil Loss during crop stage)/(Measured EI during crop stage) (1)

where soil loss units are in t/ha, and EI units are in MJ•mm•(ha•h)$^{-1}$.

SLR values using the above equation are not valid for the plots with grass hedges. Part of the credit for lower soil loss with plots with grass hedges should be reflected in an erosion control practice factor (P).

Annual SLR's were 0.007, 0.014, 0.017, and 0.013 for 1999 through 2002 crop years, respectively, for no-till UNRC on flat beds (Table 3). For conventional-till on flat beds, these annual SLR's ratios were 0.327, 0.155, 0.082, and 0.117, respectively. The UNRC average annual SLR's were 0.013 and 0.170 for no-till and conventional-till, respectively.

McGregor *et al.* (1999) published annual SLR's for standard row cotton during the 1992 through 1994 crop years of 0.019, 0.008, and 0.037, respectively, for no-till cotton on flat beds. For conventional-till standard-row cotton on flat beds, these ratios were 0.256, 0.109, and 0.248, respectively. Mutchler *et al.* (1985) reported annual SLR values for conventional-till cotton on ridges to be 0.217 for conventional-cotton after 11 years of no-till, and 0.408 for conventional-till cotton on ridges after 11 years of conventional-till. They reported annual SLR values for no-till cotton after reduced-till soybeans of 0.102.

Cotton Yields and Ground Residues: Cotton yields were not significantly different ($\alpha = 0.05$) for the four treatments; however, a significant year effect was found with higher yields in each of the four treatments during 2001 and 2002 as compared to the yields in 1999 and 2000 (Table 4). The overall average yields and residues for the NT-G, NT-WOG, CT-G, and CT-WOG were 1637, 1642, 1624, and 1442 kg/ha and 4.3, 4.2, 4.2, and 3.2 t/ha, respectively. These yields and residues averages show a trend that conventional-till without grass hedge results in lower yields and residues as compared to no-till with and without grass hedges and conventional-till with grass hedge.

Table 3 Annual soil loss ratios (SLR) computed using measured soil losses and estimated annual EI values.

CROP			NARROW-ROW COTTON STUDY			
YEAR	**RAIN**	**EROSION INDEX**	**NT-G†**	**NT WOG†**	**CT-G†**	**CT WOG†**
	(mm)	**(MJ mm (ha h)$^{-1}$)**	**P(SLR)**	**SLR**	**P(SLR)**	**SLR**
1999	990	5110	0.015	0.007	0.037	0.327
2000	1041	4906	0.012	0.014	0.021	0.155
2001	1733	11634	0.007	0.017	0.013	0.082
2002	1516	6756	0.006	0.013	0.015	0.117
4 year-average	**1320**	**7102**	**0.010**	**0.013**	**0.022**	**0.170**

CROP			STANDARD ROW COTTON STUDY			
YEAR	**RAIN**	**EROSION INDEX**	**NT-G†**	**NT WOG†**	**CT-G†**	**CT WOG†**
	(mm)	**(MJ mm (ha h)$^{-1}$)**	**P(SLR)**	**SLR**	**P(SLR)**	**SLR**
1992	1464	7984	0.011	0.019	0.052	0.256
1993	1376	6792	0.005	0.008	0.027	0.109
1994	1343	8660	0.013	0.037	0.073	0.248
3 year-average	**1394**	**7812**	**0.010**	**0.021**	**0.051**	**0.204**

† NT = no-till, CT = conventional-till, WOG = without grass hedge

Notes: SLR = 33.95(Soil Loss/EI) for plots without hedges, and where P (the erosion control practice value in RUSLE) equals 1.0; but P(SLR)= 33.95(Soil Loss/EI) for plots with hedges and the value of P is less than 1.0. Holly Springs EI estimated as being 91.5% of EI measured at Goodwin Creek Watershed. Based on 19 years of records at both locations. P(SLR) is the product of the P factor and the annual soil loss ratio (or annual C factor). P(SLR) values are shown for plots that had grass hedges. SLR is the crop year annual soil loss ratio or "annual C" factor. SLR values are shown for plots without hedges.

SUMMARY AND CONCLUSIONS

Low soil loss ratios computed for use in soil loss prediction reflected the erosion control potential of non-ridged, no-till, ultra narrow-row cotton. Average annual runoff was highest for ultra narrow-row cotton treatments of conventional-till without grass hedges followed by conventional-till cotton with hedges, no-till cotton with hedges, and no-till cotton without hedges. Runoff from all no-till plots (with and without hedges) was 45% less than runoff from all conventional-till plots. Hedges reduced average annual runoff on conventional-till cotton plots by 40%, but runoff from no-till plots with hedges was 9% higher than from no-till plots without hedges.

Ultra narrow-row cotton conventional-till plots with hedges as well as the no-till plots with and without hedges controlled annual soil losses to less than the tolerance value of 7 t/ha during the 1999-2002 crop years. Average annual soil losses were highest for conventional-till cotton without grass hedges followed by conventional-till cotton with hedges, no-till cotton without hedges, and no-till cotton with hedges. Hedges reduced average annual soil loss on conventional-till cotton plots by 87% and on no-till plots by 37% during the 1999-2002 crop years.

Table 4 Crop Yields and Residues during the 1999-2002 Crop Years.

CROP YEAR	TREATMENT	COTTON YIELD (kg/ha)	RESIDUE (t/ha)
1999	NT-G†	990	4.9
	NT-WOG†	1216	6.0
	CT-G†	1107	5.2
	CT-WOG†	1123	4.9
2000	NT-G†	1339	3.8
	NT-WOG†	1178	3.8
	CT-G†	1172	3.3
	CT-WOG†	1284	2.7
2001	NT-G†	2346	4.1
	NT-WOG†	2167	3.8
	CT-G†	2233	4.1
	CT-WOG†	1655	2.4
2002	NT-G†	1874	4.6
	NT-WOG†	2006	3.4
	CT-G†	1982	4.3
	CT-WOG†	1704	2.9

† NT = no-till, CT = conventional-till, G = grass hedge and WOG = without grass hedge
Crop Residues collected after harvest.

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