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CROPLAND EROSION RESEARCH - 1989 RESULTS

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March 16, 1990

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Col. Frank R. Skidmore
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Dear Sirs:

The enclosed reports give results of our cropland erosion research conducted in 1989 at the Nelson Farm and at the North Mississippi Branch Experiment Station. Please note that most of these experiments are designed to last several years so that a variety of rainfall and temperature patterns help make the results more reliable. Also, the results will require more analysis before being ready for formal publication.

We appreciate the assistance of our cooperators in these projects - the Soil Conservation Service and Mississippi Agricultural and Forestry Experiment Station.

We recognize your requests for research information at the earliest time possible and hope that these reports are helpful. For further information on this research, I suggest you call Mr. Bill Lipe, SCS Liaison to the Laboratory.

Sincerely,

Carl

C. K. MUTCHLER
Laboratory Director

Enclosures

EROSION RESEARCH AT HOLLY SPRINGS WITH SOYBEANS AND GRAIN SORGHUM

This research report summarizes cooperative work on erosion control with conservation tillage systems by ARS and MAFES at the North Mississippi Branch Experiment Station, Holly Springs, MS. These data are all preliminary to publication and will require further analysis before publication.

Soil erosion effects on soybean productivity

This study was begun in 1983 to measure and document the loss of soil productivity as erosion progresses. Soybeans were grown each year on twelve pairs of plots on sites with similar soils and overland slopes of about 3%. No-till soybeans were grown in one plot of each pair and conventional-till soybeans were grown in the other plot. In the early years, yields from conventional-till exceeded those from no-till, but crop yields from no-till exceeded those from conventional-till during the last three years. The 7-year average crop yields were 27 and 25 bushels per acre for no-till and conventional-till soybeans, respectively. However, the decrease in yield after 4-years of excessive erosion clearly shows the effect on erosion and soil productivity.

Treatment	Soybean Yield						
	1983	1984	1985	1986	1987	1988	1989
	bu/acre						
No-till	13	35	39	19*	30	33	20
Conventional-till	16	39	40	20	26	19	17

* Stem canker reduced yield

A rainulator was used to apply simulated rainfall to the bottom third of one pair of plots in 1986 and another pair in 1987. Immediately preceding the tests, both the no-till and conventional-till plots used in the rainulator experiments received tillage of two diskings and harrowing. Plots with conventional-till history were more erosive than those with no-till history, even though tillage immediately preceding soil loss measurements were identical. Soil loss measured during the rainulator experiments was 32% greater from plots with a conventional-till history in the 1986 rainulator evaluation and 24% greater in 1987. A similar experiment is planned for 1990. These results show that soils with significant erosion problems are more susceptible to further erosion than soils protected through a no-till or minimum-till management system.

Ridge-till vs no-till grain sorghum

Five-year average (1985-1989) rainfall, runoff, soil loss and crop yield data from 1/4-acre plots in no-till grain sorghum with 20-inch contoured rows, 1/4-acre plots in ridge-till grain sorghum with 40-inch contoured rows, and 0.022-acre plots in ridge-till grain sorghum with 40-inch rows up and downhill are given in the following table. The data show that contouring benefits crop yield and reduces soil loss.

Treatment	Rainfall	Runoff	Soil loss	Crop yield
	(inches)	(inches)	(tons/ac)	(bu/ac)
20-inch contoured rows, no-till	50	13	0.5	63
40-inch contoured rows, ridge-till	50	12	0.9	62
40-inch up and down rows, ridge-till	50	11	2.1	55

Another grain sorghum tillage study consisted of no-till with conventional-till history, no-till with no-till history, conventional-till and reduced-till (no-till planted and cultivated). These treatments were conducted on 0.022-acre plots with two replications of each treatment. Three year average (1987-1989) rainfall, runoff, soil loss and grain yield data are summarized in the following table. These data are from standard erosion plots and can be used to verify or modify models that predict erosion from reduced tillage systems.

Treatment	Rainfall	Runoff	Soil loss	Grain Yield
	(inches)	(inches)	(tons/acre)	(bu/acre)
No-till				
Conventional-till history	53	16	2.1	52
No-till history	53	5	0.1	64
Conventional-till	53	11	4.0	48
Reduced-till	53	11	3.0	57

Data are also available from two 1/4-acre plots with overland slopes of 2 1/2% in which no-till grain sorghum was grown on contoured rows; however, one plot was para plowed (deep tilled) several days before planting. Average three year (1987-1989) rainfall, runoff, soil loss and grain yield data are presented in the following table. It appears that para plowing tended to reduce runoff and increase grain yield.

Treatment	Rainfall	Runoff	Soil loss	Grain yield
	(inches)	(inches)	(tons/acre)	(bu/acre)
No-till	53	8	0.1	65
No-till + para plowing	53	6	0.1	76

Cropland Management Research at the Nelson Farm

This report summarizes results from the first two years of NSL's cooperative research with MAFES and SCS that is directed toward the development of cost-effective crop production systems which reduce soil erosion. The research is being conducted at the A. E. Nelson farm south of Senatobia, MS on several scales: economic yield production plots, natural-rainfall erosion plots, rainfall simulator erosion plots, and watersheds. A number of supplementary agronomic studies have also been started to clarify details of the management of winter legume cover crops, the value of planting in narrow rows, the importance of earthworms, the feasibility of growing corn on these soils, and the use of contour vetiver grass hedges to trap eroded sediment. Results to date are preliminary and will require further analysis before publication.

Production Research

Studies of crop yields from different production systems is cooperative with MAFES researchers. In the main production plots, three summer crops are being grown under four tillage systems: conventional tillage, ridge tillage, reduced (one-pass) tillage, and some form of no-tillage (Table 1). The no-till soybean treatment is double-cropped with winter wheat; the no-till cotton and grain sorghum treatments involve planting into winter cover crops of wheat and vetch, respectively. An additional no-till treatment, a two-year rotation of grain sorghum followed by wheat double-cropped with soybean, provides a harvest of each crop each year.

Table 1. Yields of Nelson Farm production treatments during 1988 and 1989.

System	DES 119 Seed Cotton 1988	DES 119 Seed Cotton 1989	Funk G-1602 Sorghum 1988	Funk G-1602 Sorghum 1989	Soybean[1,2] 1988	Soybean[1,2] 1989	Florida 302 Wheat 1988	Florida 302 Wheat 1989
	------ lb/acre	------			------ bu/acre	-----		
Conventional tillage[1]	1830	1230	3990	4240	20.5	20.2		
Ridge tillage[1]	1560	960	3710	3920	20.4	21.9		
One-pass tillage[1]	1430	1080	3930	4250	23.5	19.6		
No-till (wheat cover)	1560	890						
No-till (vetch cover)[3]			3580	4780				
No-till (soybean-wheat double-crop)[2]					24.7	26.7	81.0	29.7
No-till (soybean-wheat/sorghum)[2]			3160	5290	--	24.0	77.4	40.2

[1] 'Bedford' soybean planted in May
[2] 'Centennial' soybean no-till planted in June after wheat harvest
[3] received 75 lb/a less N than other sorghum treatments

During 1988, one-pass and no-till cotton treatments were planted in a small trench because residue removing devices (trash whippers) were set too deeply. These treatments grew-off slowly because of soil temperature, moisture, and fertility factors. All cotton was planted well in 1989, but was severely stunted by contaminated insecticide applications 8 to 10 weeks after planting. This delayed maturity and reduced yields of all treatments. It was necessary to cultivate no-till cotton both years to control perennial weeds, so little residue mulch has built up in this treatment to date. Both no-till sorghum treatments had to be re-planted in 1988 because of poor stands. This resulted in delayed maturity and lower grain yields for these treatments. In contrast, during 1989, the no-till treatments yielded most. In 1989, Roundup was applied earlier (26 days before planting), and insecticide granules (Lorsban) were applied as a band over each row in all treatments. No replanting was needed. Rainfall was abundant during May (3.7"), June (13.4"), and July (6.6") of 1989, and this seemed to favor the no-till treatments of both sorghum and soybean in the second year of no-till. The same was not true of cotton where cultivation for weed control disturbed the soil surface each year.

Full-season soybean yields were reduced by insects and/or diseases during both 1988 and 1989. Yields were approximately one half of the yield potential anticipated for this location. Stinkbug feeding during pod fill reduced yields in 1988, with damage being greatest in plots located close to grain sorghum plots. During 1989, stem canker reduced yields of all full-season soybeans. In future years, 'DPL 415', which has some resistance to this disease, will replace 'Bedford' as the full-season cultivar. Double-crop soybean yields were reduced by the same factors in each year, but to a lesser extent than full-season beans.

Wheat yields were very good in 1988. Wheat was planted in 1987 into a seedbed prepared on old pastureland which had been chisel plowed twice, limed, and fertilized for the initiation of the experiment. Very dry weather prevailed during May 1988 and no disease was evident. During 1989, in contrast, sceptoria terminated growth of wheat during early May. Wheat following soybean was planted about one month later than wheat following grain sorghum, because stinkbugs delayed soybean maturity and harvest during 1988. This delay resulted in more winter damage and greater yield reduction from septoria infection for the double-crop treatment in 1989.

Determination of net return for each crop system has been completed only for 1988 (Table 2). In that year, net returns ranged from a negative $52.27 for no-till grain sorghum with a vetch cover crop to $229.93 for the no-till soybeans double-cropped with wheat. The high net returns for the soybean/wheat double-crop were attributed to the unusually high wheat yields that year and to the relatively low production costs of wheat. At the present time, it is premature to definitively assess the economic feasibility of the various crops or crop rotations. Several years of data will need to be evaluated before solid recommendations can be given on which crops and/or rotations will potentially be most profitable.

Table 2. Net returns[1] from production treatments during 1988.

System	Seed Cotton	Sorghum	Soybean[1,2]	Wheat
	---------------- dollars/acre ----------------			
Conventional tillage	$61.06	$-16.95	$13.05	
Ridge tillage	11.98	-31.38	-5.36	
One-pass tillage	-23.92	-34.68	12.74	
No-till (wheat cover)	2.54			
No-till (vetch cover)		-52.27		
No-till (soybean-wheat double-crop)			28.40	201.53
No-till (soybean-wheat/sorghum)		-74.49	26.46	190.91

[1]Crop production costs are based on 1988 prices, and returns received are based on a 5-year average (1984-1988): cotton lint ($.59/lb); cotton seed ($.03/lb.); grain sorghum ($4.11/cwt.); wheat ($3.21/bu.); and soybeans ($5.96/bu.).

Earthworm study

A study was initiated during 1989 to determine the interrelations of earthworm populations, tillage systems, and water infiltration rates. Five treatments are: fertilized grassland, conventional till (chisel, double disk) soybean, no-till soybean, "optimal" soybean, and "optimal" soybean plus vermicide. Irrigation, winter wheat/vetch cover crop, and no-till management constitute what is called the "optimal" treatment from the standpoint of earthworms when producing soybean. The identical treatment except with a vermicide (worm killer) applied to reduce earthworm activities will allow estimation of the earthworm influence on yield and water infiltration rates apart from the tillage, cover, and irrigation. The first vermicide was applied after soybean harvest in 1989.

Trickle irrigation tubing was placed 6" underground on 36" centers during March 1989 using a vibratory plow which caused minimal soil disturbance. Soybeans were no-till planted on top of the irrigation tube or in non-irrigated no-till or conventional-tillage plots. No-till planted soybean yield was higher than following tillage in 1989 (Table 3). Trickle irrigation increased no-till yields 5 to 7 bu/a by reducing the severity of stem canker symptoms and delaying leaf drop.

Earthworm populations appeared to be higher in the no-till than in the conventional-till treatments but little difference has been found between the no-till grass and no-till soybean, with or without irrigation. Soil moisture measurements indicated soils under soybean were considerably drier (prior to irrigation) during August than soil under grass. A total of 3 inches of irrigation water was applied to the optimal treatments in 1989.

Table 3. Soybean yield and earthworm populations, Nelson Farm, 1989.

System	Bedford Soybean Grain Yield	Earthworm Populations June	Sept	Dec
	bu/acre	---- number/m^2 ----		
Conventional tillage	16.5	17	68	56
No-tillage	23.3	52	211	79
No-till plus irrigation	30.6	65	157	67
No-till, irrigation, and vermicide	28.6	79[@]	171[@]	57
Fertilized grassland (internal control)		103	122	116
Unfertilized grassland (external control)		37	69	50

[@] First vermicide (benomyl) application not made until November 1989

Soybean Row Spacing/Herbicide Study

An interaction may exist between row spacing and pre-plant tillage on the value of preemergence herbicides and on soil erodibility. Narrow rows (7") result in earlier season canopy closure and greater crop competitiveness with weeds. Surface residues (no-till planting into crop and weed residues) may suppress weed germination and growth through mulch effects, but may also reduce the effectiveness of soil-active herbicides by intercepting them. The result can be a lower degree or shorter duration of weed control attributable to preemergence herbicides in high-residue, no-till environments; so narrow-row planting may be of greater value to weed control in no-till than in clean-till environments. With regard to erosion, residues and denser crop canopy may both reduce raindrop splash and runoff velocities, thus reducing soil loss. However, no-till planting in narrow rows results in more residue disturbance than no-till planting in wide rows; so the potential erosion control gains from narrow-row planting may be less for no-till planting than for clean-till.

First-year soybean yields (Table 4) demonstrated that preemergence herbicide treatments increased soybean yield relative to the no herbicide treatments. In this study, "no herbicide" refers to no preemergence herbicide; a burndown treatment of 1 quart Roundup was applied to all no-till treatments. Further statistical analysis indicated that a significant interaction existed between tillage and row spacing. Inspection of the data indicates that narrow-row planting was superior to wide-row planting for no-till, while this was not true for conventional tillage plantings.

Net returns for 1989 largely reflect the yield trends (Table 4). Narrow-row soybean showed little response to herbicide use. Response to herbicides was larger following tillage and for wide-row planting. Cultivation resulted in lower production costs than relying strictly on post-emergence treatments.

Table 4. Soybean yield and net return[@] from tillage/row spacing study.

System	1989 Bedford Soybean Yield Till	1989 Bedford Soybean Yield No-till	Net Return Till	Net Return No-till
	bu/acre		dollars/acre	
Drilled				
No Herbicide	19.7	24.9	27	47
All Postemergence	24.2	29.5	31	47
Canopy Pre	28.8	29.7	65	60
Canopy and Dual Pre	26.4	31.1	39	56
36" Rows - Cultivated				
No Herbicide	25.0	22.3	50	24
Canopy Pre	27.2	30.3	52	60
Canopy and Dual Pre	33.8	28.8	78	39
36" Rows - Not Cultivated				
Canopy and Dual Pre	31.0	29.0	54	37
	LSD(0.05) = 3.7			

[@] Exclusive of land and management; based on $5.96/bu soybean

Corn Study

A study begun in 1989 compares 8 tillage systems for corn. Corn is of increasing interest with the development of postemergence herbicides which control johnsongrass. It is a suitable rotation crop for cotton or soybean. Because of easy stand establishment characteristics, it is a good choice for farmers interested in gaining no-till experience.

The treatments are comparable with and provide additional information for interpretation of the other production plot treatments. Three of the corn treatments are analogous to the conventional, ridge till, and one-pass tillage treatments of the main production treatments. The five additional treatments are: no-till, no-till with corn residues removed before planting each year (residues will remain on all other treatments), no-till into killed sod (no pre-experiment tillage of old pasture), and shallow preplant tillage (disking only) with and without postemergence cultivation (the 3 no-till treatments will also not be cultivated). Weed control and fertility are maintained at high levels in all treatments. Various comparisons of these treatments test the value of corn residue mulch (in the absence of cultivation), the need for deep tillage (chisel plowing), the need for cultivation to break up crusts (in the absence of mulch), and the need for preliminary tillage and lime/fertilizer incorporation when bringing pasture into no-till crop production.

During 1989, 20 inches of rain fell during June and the first half of July at the Nelson Farm. All corn treatments yielded between 129 to 155 bu/a (Table 5), and no statistically significant differences were attributable to intended treatment comparisons.

Table 5. Nelson Farm corn study grain yield, 1989.

System		Pioneer 3165 Corn Grain Yield
		bu/acre
Chisel/disk tillage	(Cultivate)	151
Ridge tillage	(Cultivate)	148
One-pass tillage	(Cultivate)	132
No-till (with residues)		138
No-till (residues removed)		129
No-till into pasture sod		157
Disk tillage	(Cultivate)	129
Disk Tillage	(No Cultivation)	155

Soil Analyses

Soil samples were collected in April, 1988 from production plots at the Nelson Farm and characterized for several parameters to establish initial soil conditions. Analyses indicate that soil characteristics at the site compare favorably with ranges in soil properties normally encountered in the loess belt of north Mississippi. Results from the top 6 inches across all reps indicated that organic matter averaged 1.6%, pH 6.2, cation exchange capacity 11.1 meq./100 g., P 43 lbs/acre, and K 133 lbs/acre. Particle size analysis and organic matter characterization are not yet completed. Additional samples will be collected near the end of the study to determine how the various conservation tillage treatments affected these properties which influence plant growth and yields.

Rainfall Simulator Studies

Erosion from a simulated storm of 2.5-inches of rain falling in one hour and runoff equivalent to a 240-ft slope (Table 6) indicated that cultivation 1 to 2 days prior to the rainfall event had a larger influence on potential soil loss than preplant tillage or row spacing. In this study, all cultivation was up and down the 6% slope, and over 10 inches of natural rainfall fell on the plots during the 4 to 7-week period between planting and cultivation or the simulated rainstorms. Although this natural rainfall caused little erosion of the plot areas, it did result in consolidation of the conventionally tilled soil. Additionally, a blue-green algal "skin" grew on the soil surface which reduced soil detachment during simulated rainfall. Despite the skin, when only the non-cultivated plots were considered, a significant interaction of tillage and row spacing was found. Although no-till resulted in less erosion than conventional tillage, narrow rows resulted in more erosion than wide rows, a result attributed to soil disturbance during planting.

Table 6. Soil loss from one hour of intense simulated rainfall on a 6-percent 240-foot slope.

System	Pre-plant tillage	
	Till	No-till
	tons/acre	
Drilled	2.6	1.2
36-in row (not cultivated)	2.2	0.5
36-in row (cultivated)	25.0	14.9

Four management practices that are being studied on the production plots were tested for erosion using a rainfall simulator. A series of intense rainstorms plus added runoff to simulate much longer slopes were studied on (1) conventional soybean, (2) no-till soybean, (3) soybean double cropped with wheat, and (4) no-till grain sorghum. Soil losses from the rows of 4% gradient during early summer are given in Table 7. These results show that all of these practices except conventional management were effective in erosion control for the row crops studied.

Table 7. Erosion from Different Rowcrop Management Practices

Management Practice	Soil Loss (tons/acre)	
	First hour, rain only	Second hour, rain + inflow
Conventional SB	1.89	6.94
No-till SB	.07	.24
Dbl crop W-SB	.01	.03
No-till GS	.25	.72

Runoff and Erosion on Plots and Watersheds

Runoff and soil loss are being measured on 16 erosion plots and three field-sized watersheds. The plots consist of two replications of eight selected cropping systems including conventional, ridge-tilled, and no-till soybean; double-cropped wheat-soybean; and no-till grain sorghum and cotton with and without cover crops. All watersheds were cropped to reduced-tillage soybean the first year to evaluate watershed comparability, but a different production system will be imposed on each in the future. Measurements were begun on most of these conditions during 1989, so results are not yet available.

Water Quality Research

During the fall of 1989, one watershed was instrumented for ground water research. At each of three sites within the watershed, observation wells, wave guides for TDR (soil moisture), tensiometers, and ceramic cup samplers were installed above and within the fragipan at soil depths of 6 to 60 in. Surface runoff is being measured and sampled for pesticides and nutrients.