USDA-ARS EROSION CONTROL AND WATER QUALITY STUDIES AT HOLLY SPRINGS, MS

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ABSTRACT: The erosion control effectiveness of no-till (NT) crops and grass buffer strips studies at MAFES, Holly Springs, MS on idle land being returned to row-crop production provided useful information related to the potential return to row-crop production of land previously in the conservation reserve program (CRP). Long-term effects of NT and conventional-till (CT) practices in shallow fragipan (a dense soil layer that restricts water movement and root growth) soils on soybean yields for a 16-year period revealed a decrease in fragipan depth that produced lower yields in both tillage systems with greater yield reduction from the conventional-till practice. The net soil loss for conventional-till as compared to no-till averaged 8 inches. The 2001 and 2002 soybean yield data showed that plots with a fragipan 10 inches or less from the soil surface, specifically those with conventional-till histories, produced too low of yields to be economically-viable. Topographic survey and visual observations revealed dramatic differences in elevation between no-till and conventional-till plots. Other continuing erosion control studies involving the evaluation of soil and water conservation management of broiler litter-amended systems included continuous corn with winter cover crop systems, simulation of the return of conservation reserve grassland to crop production, and reduced-till and no-till ultra-narrow row cotton with and without stiff-grass hedges. Corn yield results from the last three years showed broiler litter could be used as the nitrogen source with negligible detrimental effects to nutrient loading in runoff or shallow groundwater when used at the 4 t/A split application rate.

CITATION: R.F. Cullum, G.V. Wilson, S. Smith, Jr. and J.R. Johnson. USDA-ARS erosion control and water quality studies at Holly Springs, MS. Annual Report 2002 of the North Mississippi Research & Extension Center. Mississippi Agricultural and Forestry Experiment Station Information Bulletin 398:231-236.

KEY WORDS: Runoff, conservation, no-till, soil loss, erosion, soybean, cotton, corn.

MATERIALS AND METHODS: Runoff and soil loss measurements continued in year 2002 on 0.02- and 0.25-A plots and on 3.2- and 4.4-A watersheds. Equipment used in plots for runoff and water sampling from natural rainfall events included FW-1 water level recorders, H-flumes, and Isco pumping samplers. Runoff and sampling equipment on the watersheds included Parshall flumes, FW-1 water level recorders, and Isco pumping samplers. Twenty-four non-instrumented plots grown in soybeans were used as production plots.

The erosion studies conducted at MAFES, Holly Springs, MS. can be grouped into studies with or without broiler litter as the nitrogen source. The broiler industry is thriving in Mississippi and along with this thriving industry comes an abundance of litter, which must be utilized in an environmentally-friendly manner. Little is known about how broiler litter will affect crops such as corn and cotton. It is believed that broiler litter applied at the proper rate can be a valuable and environmentally-friendly source of plant nutrients. In some of the erosion studies, broiler litter was surface-applied to small plots and upper-third of watersheds at recommended N-rates to test the hypothesis that broiler litter may be disposed of without degrading water quality by developing economically competitive conservation-tillage cropping systems. Crop and tillage management systems with organic additives are being evaluated for their affects on water quality of surface runoff and shallow groundwater using field experiments with plots and watersheds. The experiments include the following studies: (A) continuous corn with winter cover crop systems, (B) return of conservation reserve grassland to crop production, and (C) reduced-till and no-till ultra-narrow row cotton with and without stiff-grass hedges. Other erosion studies that did not use broiler litter included: (D) long-term soybean production and (E) stiff grass hedges.

A. Continuous corn with winter cover crop study - To evaluate application to continuous corn with winter cover crop, broiler litter is being applied at 4 t/A in split applications to 0.02-A instrumented plots under no-till, reduced-till, and conventional-till. A winter cover crop (wheat) is being planted to act as a nutrient scavenger. Periodic sampling and analysis of shallow groundwater and surface runoff is being performed for nutrients (N and P), metal (Cu and Zn), metalloid (As), non-metal (Se), and pesticides. Soil P levels will be determined to predict water quality through measurements of basic soil P parameters such as P saturation, EPC, labile P, extractable P, and standard P sorption isotherms. Soil and plant tissue (grain and cover crop) samples will be analyzed for nutrients and metals. Crop yields are being collected for comparison of yield to soil loss and runoff. Yield is being determined for each plot. Plots are equipped with data loggers, FW-1 water level recorders with potentiometers, H-flumes, tipping buckets connected to subsurface field drains, water samplers, and shallow groundwater wells ranging from 0.15 to 6.1 m. The experimental design for determining extent of chemical leaching to groundwater or chemical moving with runoff as a function of tillage practices consisted of growing corn annually on a randomized block design with three levels of tillage (no-till, reduced-till, and conventional-till) replicated twice.

B. Return of conservation reserve grassland to crop production study - Conservation technologies at the watershed scale are being evaluated for their ability to improve water quality from crop and pasturelands receiving broiler litter applications. Runoff and shallow groundwater data is being collected from two small watersheds (3.2- and 4.4-A) where combinations of conservation technologies are used to control soil erosion. Fescue grass buffer strips were established on two watersheds in the fall of 1993. Practice combinations studied on one watershed include a rotation of no-till corn and no-till cotton combined with fescue buffer strips, and continuous grass with fescue buffer strips and stiff-grass hedges on another watershed. Poultry litter is being applied only in the upper portions of both watersheds at 4 t/A. Watersheds are equipped with groundwater wells, Parshall flumes, and Isco pumping samplers. Runoff, soils, and plant tissues are analyzed for nutrients and metals. Nonparametric tests will be used to compare sediment and nutrient concentrations and losses between the two watersheds and from time periods before and after application of poultry litter. The Kolmogorov-Smirnov two sample test statistic, T, will be used to test the null hypotheses: there is no significant difference in sediment or nutrient concentration (primarily nitrates and phosphates) or loss distribution functions for the two watersheds and from the before and after broiler litter application periods.

C. Reduced-till and no-till ultra-narrow row cotton with and without stiff-grass hedges study - The effect of ultra-narrow row no-till cotton and ultra-narrow row reduced-till cotton with and without stiff-grass hedges with broiler litter applications on runoff and soil loss is being evaluated on 5% sloping, 0.02-A plots. The experimental design is a randomized incomplete block with two factors. Plots are equipped with FW-1 water level recorders with potentiometers, data loggers, H-flumes, and Coshocton runoff sampling devices. Poultry litter was applied at 2 t/A on treatments that included no-till cotton with and without narrow stiff-grass hedges, and reduced-till cotton with and without hedges. The fifth treatment included no broiler litter added to a no-till practice with no hedge. The stiff-grass hedges are located across the outlet of the plot to trap sediment and slow runoff. Sediment, nitrate, and phosphate losses are being analyzed from collected runoff samples from natural rainfall events. Cropping and management C-factors derived for conservation tillage practices for use in RUSLE will be determined for these systems. Crop yields from each of the 10 plots are being evaluated and compared to yield from standard row cotton grown at similar sites at the Northern Branch MAFES at Holly Springs, MS.

D. Long-term soybean erosion study - Soybean yield from continuous no-till and conventional-till systems were measured for 16 years (1984-1999) on 12 pairs of 150-ft long up-and-down-hill plots. Each pair had one no-till subplot and one conventional-till subplot. Six sequential 25-feet long slope subplots or segments within each plot were designated as A through F with segment A at the top of the plot. Simulated rainfall was applied in the lower one/third of the plots, segments E and F, during some years. Thus the upper two-thirds (100 ft) of all plots (sub-plot segments A, B, C, and D) were used to evaluate yields to provide continuity for subsequent experiments and to avoid conflicts in interpretation of yield data. All plots had been cultivated in the spring of 1983, but no-till plots had not been cultivated again until some were cultivated in a revised study that began in the year 2000. The revised study began in the fall of 1999 when 8 plots were planted in wheat for new soybean-wheat double-cropped plots. The study was changed from the long-term no-till and conventional-till plot arrangement (12 paired plots) to a factorial arrangement with three treatments with strips of two histories (no-till and conventional-till). Treatments were no-till soybean, conventional-till soybean, and no-till soybean with winter wheat.

E. Stiff grass hedges study - Stiff grass hedges on a 0.3 percent grade were established in 1995 on two 0.25-A corn plots. Water that flowed through a stiff grass hedge on a plot flowed through an H-flume, while water that was diverted laterally by the grass hedge flowed through another flume. A related stiff grass study on 0.02-A cotton plots began in 1999. In that study, stiff grass hedges extended across duplicate 0.02-A cotton plots at the lower ends of the plots. The plants had been transplanted in the spring of 1991. Runoff was measured and sampled for each natural rainfall event to determine sediment trapping efficiencies and soil loss.

RESULTS AND DISCUSSION: Rainfall on unprotected soils causes severe soil erosion. Many soil properties, such as particle size distribution, cohesiveness, structure, and hydraulic properties, affect the erosion process. Residue cover is a critical factor. Crop residues left on the ground surface provide protection of the soil surface from the impact of raindrops and slow the rate of runoff, thereby, increasing the infiltration (decreased total runoff) and providing small reservoirs for sediment deposition. Heavy crop residue on moderate slopes and low slope lengths may reduce erosion potential from runoff to where very little rill erosion will occur. Field experiments under simulated and natural rainfall demonstrate that surface crop residues effectively reduce erosion. Residue cover, canopy cover, and minimal soil disturbance help to protect the soil surface.

The Revised Universal Soil Loss Equation (RUSLE) has wide applicability for use in conservation planning. The RUSLE equation allows conservationists to select a conservation plan that will provide maximum soil loss protection. The cropping and management (C) factor for use in RUSLE is defined as the ratio of soil loss from land cropped under specified conditions to the corresponding loss from tilled continuous fallow land. Cropping and management C-factors derived for conservation tillage practices for use in RUSLE are considerably lower than those for conventional-till. Data over the last 40-years at Holly Springs have contributed towards improving C-factors for conservation systems for use in RUSLE. Further, data from current ultra-narrow row cotton production is being used to adjust the C-factor used in RUSLE for standard cotton to give credit for the additional ground cover.

Cropping and management factor values (C-Values) derived from storms larger than 1.4 inch provided good estimates for use in RUSLE for predicting soil losses for land with no-till and conventional-till soybean, corn, or cotton cropping systems. Conservation tillage cropping systems for corn (grain and silage), soybean, and cotton from 1974 to 2002 at Holly Springs effectively controlled erosion, especially as compared to conventional-till. Soil losses from agricultural land previously under conventional-till were dramatically reduced.

Continuous corn with winter cover: Corn yields were maintained when converting nitrogen sources from commercial fertilizer to broiler litter in the three tillage systems (no-till, reduced-till, and conventional-till). For the 2002 water year (Oct 1, 2001 to Sept 30, 2002), runoff and shallow groundwater samples showed no significantly high nitrate concentration levels. The residue cover from the previous corn crop and the winter wheat as a nitrogen scavenger provided erosion controlled measures during the late fall, winter, and early spring period when high intense storms typically produce the most erosion in this region.

Return of Conservation Reserve Land to Crop Production: When grass-land, eligible for release from the Conservation Reserve Program (CRP), is converted to cultivated row crops such as cotton and corn, soil erosion rates may be too high to be acceptable. No-till cotton and corn (cotton-corn rotation) followed grass on a watershed (WS-1; 3.25 A) at Holly Springs, MS in 1994. Continuous no-till cotton followed grass on a second watershed (DB-1; 4.4 A). Twenty-foot wide grass strips were maintained between cultivated areas in both watersheds to trap sediment and reduce off-site transport.

The average water year (Oct. through Sept.) rainfall (1994-2002) was 55 inches, or about two inches more than normal annual rainfall. Average annual runoff was less (6.5 vs 8.8 inches) and average annual sediment yield was greater (0.3 vs 0.08 t/A) on the DB-1 watershed as compared to that from the WS-1 watershed during the 1994-2002 water years. But the runoff and sediment yield values on both watersheds were low. The low values of runoff and sediment yield did not reflect, however, the erosion that was taking place within the DB-1 watershed. Numerous rills and gullies formed in the DB-1 watershed by the end of the summer of 1997. The shallow fragipan soils contributed to the erodibility of the ground surface on the DB-1 watershed. We believe the increased erodibility resulted from reduced infiltration rates, limited water storage capacity, and lower hydraulic conductivities associated with the fragipan soils.

The runoff and eroded soil amounts leaving both watersheds were very low for one and one-half years before and four years after the no-till corn-cotton rotation was grown on one watershed and continuous no-till cotton was grown on the other watershed. Nevertheless, the continuous no-till cotton watershed had to be returned to grass because of the development of rills and small gullies within the watershed during the fourth year after conversion from sod. The soil erosion took place within that watershed because a shallow fragipan limited water infiltration into the soil. Rill development and gully formation was not a problem on the other watershed with the rotated crops, which also did not contain a fragipan. Results from these watershed studies should be useful to conservationists and farmers in selecting CRP watersheds that can be successfully returned to row-crop production.

Long-term Soybean Study: Annual crop yields of long-term no-till soybean (*Glycine max*) and conventional-till soybean were summarized for a 16-year period, 1984-1999. The silt loam soils at the North Mississippi Branch Experiment Station are representative of the severely eroded loess of the southeastern United States. The soybean plots were located on a shallow Loring *(Typic Fragiudalf*) silt loam soil that was underlain by a restrictive fragipan. The no-till provided minimal erosion and the conventional-till provided excessive erosion.

The crop yield data indicated probable trends for increasing soil losses with time under conventional-till history, and decreasing soil losses with time for no-till history. Estimations of soil loss using RUSLE indicated that greater erosion from conventional-till occurred on slope segments from 50 to 100 ft as compared to those from 0 to 50 ft. This greater erosion apparently contributed to a decrease in soil productivity on the shallow Loring silt loam soil.

Differences and trends in crop yields between no-till and conventional-till soybean on a soil overlaying a fragipan were recorded over the 16-year period. Crop yield results and computations with RUSLE indicated that soil loss from conventional-till soybean on fragipan soils reduced long-term crop productivity, while the soil resource base was maintained on these soils under no-till soybean. Crop productivity under no-till also was maintained at a higher level than under conventional-till.

A recent topographic survey revealed dramatic differences in elevation between no-till and conventional-till plots after 17 years that represented much more erosion under conventional-till than predicted with RUSLE. Elevations in each of the conventional-till consecutive A, B, C, and D down-slope segments averaged 6, 4, 9, and 9 inches less, respectively, than those measured for the no-till segments. The soil loss for the 100-ft long ABCD reach for conventional-till soybean averaged 8 inches more than the soil loss from no-till soybean.

Although poor soybean yields from both no-till and conventional-till were produced during several years, the sustained trend for lower yields from conventional-till as compared to no-till indicated an adverse effect of excessive erosion and tillage on soil productivity. Continued erosion of the soil overlying a fragipan soil creates an environment where crop yields cannot be maintained even under optimum climatic growing conditions.

Stiff Grass Hedges: Analyses of data collected from plots with stiff grass hedges are still being processed.

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