Or in the case of soybeans . . .

Soil Material Above the Pan	Gallons of Available H_2O Stored/A	Bushels of Soybeans Per Acre	Dollar Value at $7.00 Per Bushel
24"	162,000	12.5	$87.50
20"	135,000	10.4	72.80
16"	108,000	8.3	57.20
12"	81,000	6.2	43.40
8"	54,000	4.0	28.00
4"	27,000	2.1	14.70

↓ Decreasing Profit Potential

The Lexington soil has no physical barrier to root development as does the Grenada, but when Lexington soils are eroded we trade high available water-holding capacity silt loam for low available water-holding capacity sand.

Plant Nutrient Losses

In addition to soil and water losses on eroded soils, plant nutrient losses associated with soil erosion is recognized nationally as a problem. The estimated value of major nutrients (N, P and K) in annual runoff is $59 per hectare (2.47 ac). This estimate may exceed current profits on many eroded farms in the Southern Piedmont. (7)

As soil is depleted from erosion phase 1 to 2, assuming all other factors of production remain constant, additional fertilizer inputs of 10 pounds of nitrogen (N), 2 pounds of phosphate (P_2O_5) and 6 pounds of potash (K_2O) are needed per acre to maintain productivity of corn at levels recommended by soil tests. (8) At today's prices, this would be $2.50 for additional plant nutrients.

(Erosion phase 1 includes those soils with only slight erosion and no mixing of surface soil and subsoil in the plow layer. Erosion phase 2 includes those soils that have some mixing of subsoil into the plow layer.)

Additional Fuel Requirements

Greater power requirements are needed for tillage operations on eroded soils. Soils in erosion phase 2 require 22 percent more fuel for tillage than the same soils in erosion phase 1. (8)

Other Losses Caused by Erosion

Eroded soils also are more susceptible to soil compaction problems in the form of plow pans and traffic pans. These compacted zones drastically shorten the effective rooting depth and seriously reduce the water-supplying capacity of the soil. Also eroded soils require heavier seeding rates to be assured of an adequate stand.

SECTION 2

EFFECTIVENESS OF SOIL AND WATER CONSERVATION PRACTICES FOR REDUCING EROSION

Proven conservation systems and good management practices can solve the most stubborn erosion problems. Such systems have proven highly effective in saving topsoil for more than 40 years. They are a key part of the individual farmer's strategy for saving his land.

Today, conservation systems take on a new importance. They play an important role in preventing water pollution from agricultural and other nonpoint sources. Erosion control is the key to clean water.

Generally, erosion is controlled within the soil loss tolerance (5 tons/ac/yr) (9) by a combination of conservation practices known as a system. Therefore, evaluating the effectiveness of a single practice for erosion control may be misleading. Generalities can only be used when discussing the reduction in erosion by use of a given system unless the system is designed for a given site.

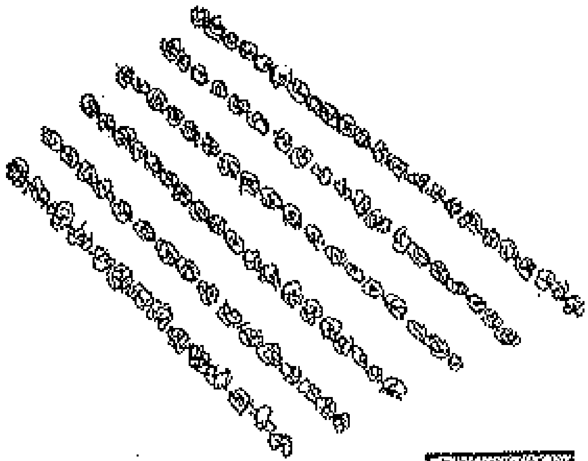
The effectiveness of a conservation system can be illustrated with the following example assuming that soybeans are grown on 4% slope, 250 feet long; the soil erodibility factor is .32; and the rainfall factor is 250. Using the universal soil loss equation, erosion can be predicted. When the soybeans are grown every year with rows up and down hill with conventional tillage, the erosion rate of 23 tons per acre per year. By adding a system of contour farming, grassed waterways, and field borders, the annual erosion is reduced to 11 tons per acre. Adding terraces to this system will reduce the erosion to 8 tons per acre per year, but is still not within an allowable level. By using conservation tillage with just grassed waterways and field borders, the erosion will be only 3 tons per acre annually. By introducing contour stripcropping and adding a sod in the rotation, the erosion will be reduced to a mere 2 tons per acre per year.

The above systems could have more or less effect on the rate of erosion on another field because soils, slope, etc. would probably be different.

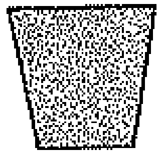
A graphic display of most of the above systems is illustrated on the following page.

COMPARISON OF DIFFERENT CONSERVATION SYSTEMS ON THE RATE OF EROSION

CULTIVATION UP AND DOWN HILL

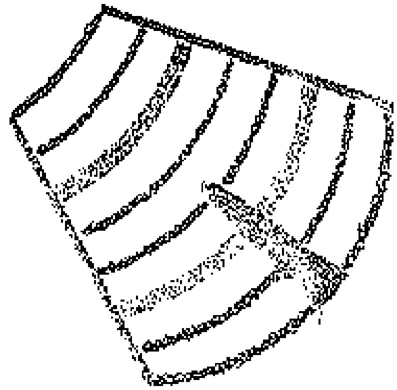


SOIL LOSS PER ACRE PER YEAR **23 TONS**

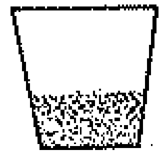


SLOPE – 4 PERCENT; 250 FEET LONG
SOIL ERODIBILITY FACTOR (K) – .32
RAINFALL FACTOR (R) – 250
CROP FACTOR (C) – .492 (CONTINUOUS SOYBEANS)
P - 1.0

CONTOUR FARMING WITH TERRACES

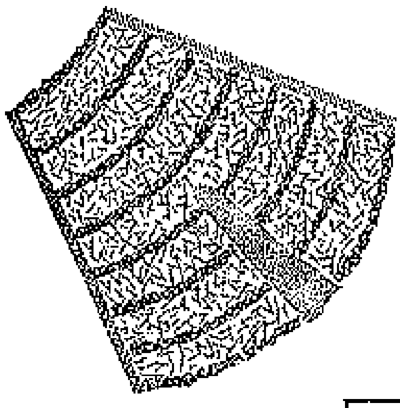


SOIL LOSS PER ACRE PER YEAR **8 TONS**

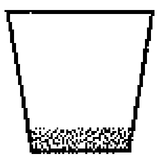


SLOPE – 4 PERCENT; 100 FEET BETWEEN TERRACES
SOIL ERODIBILITY FACTOR (K) – .32
RAINFALL FACTOR (R) – 250
CROP FACTOR (C) – .492 (CONTINUOUS SOYBEANS)
P - 0.5

NO TILL FARMING ON CONTOUR SOYBEANS IN WHEAT STUBBLE

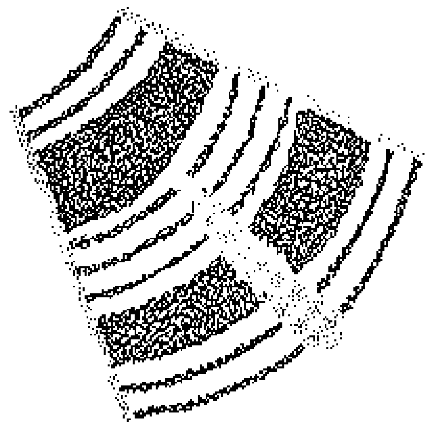


SOIL LOSS PER ACRE PER YEAR **3 TONS**

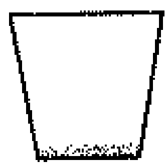


SLOPE – 4 PERCENT; 250 FEET LONG
SOIL ERODIBILITY FACTOR (K) – .32
RAINFALL FACTOR (R) – 250
CROP FACTOR (C) – .12 CONSERVATION TILLAGE SOYBEANS IN WHEAT STUBBLE WITH GRASSED WATERWAY AND FIELD BORDERS
P - 0.5

CONTOUR STRIPCROPPING



SOIL LOSS PER ACRE PER YEAR **2 TONS**



SLOPE – 4 PERCENT; 250 FEET LONG
SOIL ERODIBILITY FACTOR (K) – .32
RAINFALL FACTOR (R) – 250
CROP FACTOR (C) – .106 CORN - SMALL GRAIN, CLOVER - 7 Yr. ROTATION CONVENTIONAL TILLAGE; GRASSED WATERWAY AND FIELD BORDERS.

P - 0.35

Physical Principles of Soil and Water Conservation Practices

The physical effects of soil and water conservation practices are primarily based on control of runoff, rain splash energy and soil structure. These physical effects are discussed below.

(1) Reduction of Runoff Velocity - The velocity of moving water will be reduced whenever the total energy available for water movement is decreased. This may be accomplished by forcing the water to move laterally rather than straight down the slope, by reducing the slope of the land through landforming, or by increasing surface roughness which dissipates the water's kinetic energy. Surface roughness is effectively increased by reducing secondary tillage operations, increasing water-stable aggregates on the soil surface or by the use of a mulch cover.

Decreasing runoff velocity reduces both surface runoff volume and soil loss. A slower flow rate allows water to remain on the field for a longer period permitting increased infiltration.

(2) Increase in Surface Storage - Any obstruction in the flow path (e.g., ridges of soil or vegetation) which allows water to pool will increase surface storage. The trapped water is removed from the total surface runoff volume, which results in a decreased runoff velocity and a reduced sediment carrying capacity. This is the effect obtained by contouring; however, for large storms these ridges may break, resulting in erosion equivalent to straight row cropping.

(3) Increased Conductivity and Moisture Storage - Some practices increase connecting to the soil surface, which can greatly increase infiltration and conductivity. Soil moisture storage can be increased by either draining and evaporating moisture in the soil profile.

(4) Reduction of the Splash-Energy of Falling Rain - Rainfall striking bare soil can result in sealing of the soil surface. In many cases a surface crust is a limiting factor for water infiltration. Dissipating raindrop energy by use of a plant canopy or a mulch will greatly reduce the surface sealing effect, thus increasing infiltration and decreasing runoff volume.

(5) Improvement of Soil Structure - A change in bulk density, porosity, and percent of water-stable aggregates in soil all affect the erodibility and its capacity for water infiltration. Lower bulk density and higher porosity increase the infiltration rate of soil water. Formation of surface crust is less extensive in soils having a high percentage of water-stable aggregates. Practices which reduce tillage operations or increase soil organic matter will generally cause improvement in soil structure.

Some of the more common cropland conservation practices will be discussed below as to their effectiveness for erosion control. This is not intended to be a complete list, but are typical for much of North Carolina (10).

(1) Contour Farming - is farming sloping land in a manner that plowing, preparing land, planting and cultivation are done on the contour. Tillage operations should be as near level as practical and a continuous grade of two percent should not be exceeded for more than 100 feet. Contouring is the most effective on fields relatively free of gullies and depressions (other than grassed waterways). Contouring is very effective with crops like tobacco where the rows are "hilled" up and on short slopes from 3 to 8 percent. Contouring is much less effective when crops are "flat" planted. Contouring can result in excessive erosion when rows break over in depressions during large storms. Contouring is most effective when used in combination with diversions or terraces.

On highly erodible soil in southern Mississippi, contoured plots had only 45 percent as much runoff as straight row cropping (Saxton and Spomer, 1968) (11). On the clay pan soil, contouring was effective in reducing runoff in dry years only. Jamison et al. (1968) (12) and Stalling (1945a) (13) summarized and compared older studies on contouring versus straight row in various parts of the country. Reduction in yearly runoff ranged from 20 to 80 percent depending on climate and soil type. The success of contour farming in increasing infiltration of water is greater on permeable soils than on clayey soils as shown by Baver et al. (1972) (14).

Ritter (1971) (15) reported a 61 percent decrease in runoff volume for a ridge watershed versus contouring. Laflen et al. (1978) (16) and Baker et al. (1978) (17) reported that for three hours of simulated rain of 6.4 cm per hour, the percentage of rainfall resulting in runoff for conventional and ridge planting were 70 and 54 respectively. For the same region but larger watersheds, the four year average runoff for conventional tillage was 13% and for ridge planting was 10% of the natural rainfall.

(2) Diversion - is a channel with a supporting ridge on the lower side constructed across the slope. Diversions are usually seeded. They are used to reduce slope length or to divert water from higher ground where it is damaging cropland, etc. Diversions are often used to supplement contour stripcropping.

Diversions are very effective in reducing erosion but are less effective in reducing runoff since they concentrate flow and thus allow less time to infiltrate.

(3) Terrace - is a combination ridge and channel constructed across the slope. Terraces are not generally seeded and are installed in a series with a definite spacing depending on steepness of slope. Their main function is to reduce slope length. Although not as popular in North Carolina as they once were, broad base terraces are compatible with modern farming for uniform fields and are an effective means of controlling erosion.

Terraces are more effective in reducing erosion than in reducing runoff. Stallings (1945b) (18) reported up to a 100% reduction in soil loss for an experiment in the eastern United States. More recently, Carter et al. (1968) (19) found that soil losses were reduced by 50% due to terracing on highly erodible loamy soils of the Southern Mississippi Valley. On poorly managed soils averaging 135 MT/ha annual soil loss, terracing reduced losses to 2.3 MT/ha (Saxton and Spomer, 1968) (11).

Because terraces retain soil on the land, they considerably reduce losses of strongly adsorbed substances such as paraquat and total phosphorus (Smith et al, 1978) (20). However, since terracing does not reduce overland flow greatly, its impact on losses of moderately adsorbed substances is less pronounced, especially on the less permeable soils. Movement of moderately adsorbed pollutants is affected more by the time interval between application and first rainfall than by terracing (Smith et al., 1978) (20).

(4) Conservation Tillage - is a form of noninversion tillage that retains protective amounts of mulch on the surface throughout the year. Conservation tillage as used in this report includes the common terms no-tillage, sod planting, minimum tillage, slot planting, and other types of noninversion tillage. Conservation tillage is one of the newer and most effective conservation practices for reducing erosion especially on rolling, undulating fields that are not adapted to the more conventional conservation practices. Conservation tillage requires more herbicides and requires good management of the herbicides to produce a good crop. Crop yields from conservation tillage are comparable to convetional tillage during normal rainfall, and generally can be expected to be better than for conventional tillage during dry years.

Work done by Langdale et al. at the Southern Piedmont Conservation Research Center, Watkinsville, Georgia (21) over a 4-year period showed the following results:

Runoff - (Reduced 47%). Annual rainfall was approximately 128 cm (51 inches). Runoff was decreased from 22.5 cm (8.9 inches) with conventional tillage to 12.0 cm (4.7 inches) with double cropped, no-till practices.

Erosion - (Reduced 98%). Annual erosion, estimated by the Wischmeier-Smith erosion equation, was 71.23 metric tons/hectare (31.8 tons/acre) and 1.3 metric tons/hectare (0.58 tons/acre) for conventional and no-till respectively. This represents a 98.2% reduction in the annual erosion rate.

Sediment - (Reduced 99.5%). Annual flume-measured sediment decreased from 26.26 metric tons/hectare (11.71 tons/acre) with conventional tillage to .13 metric tons/hectare (0.06 tons/acre) with no tillage.

During five years of monitoring in Ohio, surface runoff volume averaged 1 mm per season for no-till plots while averaging 11 mm per season on conventionally tilled plots (Harrold et al, 1970) (22). Thirty-six hours after a 2.6 cm storm, soil moisture to a depth of 105 cm was 2.5 cm greater on no-till plots than on conventional plots, indicating significantly higher water infiltration under no-till (Blevins et al. 1977) (23). McDowell found a 90% reduction in overland flow for no-till corn versus conventionally tilled corn.

Numerous studies (Moldenhauer et al. 1971 (24); Harrold et al. 1970 (22); Meyer and Mannering, 1968 (25); Shanholtz and Lillard, 1969 (26); McDowell and Grissinger, 1976 (27) show that no-till is one of the most effective ways to reduce soil loss from a field. Accumulation of organic matter near the surface of the untilled soil causes significantly higher stability of soil aggregates (Blevins et al. 1977) (23). This, as well as the absorption of energy by the impact of falling raindrops and the impedance to water flow by surface trash, reduces volume and velocity.

Burwell and Larson (1969) (28), and Siemens and Oschwald (1976) (29) showed that various conservation tillage methods increase the time before runoff starts. Laflen et al. (1978) (30) showed that runoff amounts decreased as residue cover increased. Harrold (1960) (31) found that for a three-year average, the relative runoff losses from conventional tillage were twice as high as those from a plow-plant system, a conservation tillage system that deletes secondary tillage. Edwards (1972) (31) found that increasing tillage causes more runoff and less infiltration of water.

Losses of plant nutrients (soluble phosphorus and nitrates) in runoff may be higher under no-till than under conventional till due to increased leaching of dead plant residues on the surface of the soil especially during the winter if freezing temperatures break down plant cells, releasing nutrients (Barisas et al. 1978) (33).

Ten years of research by Beale, et al. (34) at Clemson University has shown that corn no-till planted in a vetch and rye mulch averaged 3.11 inches less water runoff per year, 2.38 tons/acre less soil erosion per year, and that yield was equal to or greater than that of the plowed, unmulched corn. This study also showed that the degree of soil aggregation and the stability of the soil structure increased after 10 years under the mulched treatments but was reduced considerably under the plowed check treatment.

(5) Cover Crop - is a crop of close-growing grasses, legumes, or small grain grown primarily for seasonal soil protection and for residue for conservation tillage.

This practice has it greatest effect during the non-growing season. It reduces direct runoff and soil loss in the fall, winter, and spring (Uhland and Hendrickson, 1946; Stewart et al. 1975a). Cover crops may decrease leaching of nitrates to the groundwater because of plant uptake. Studies quoted by Stewart et al (1976) show that non-legume crops are especially effective.

Cover crops might decrease the loss of strongly adsorbed pesticides which usually degrade slowly and are still available in the soil during the winter (Smith et al. 1978) (20). Most of the moderately adsorbed pesticides have short half-lives and by the time the cover crop becomes effective in reducing runoff, pesticide concentration in the water is usually negligible and the effect on total pesticide loss is minimal. Studies by Smith et al. (1978) showed this to be true for atrazine, trifluraline and 2,4-D in Watkinsville, Georgia.

(6) Grasses and Legumes in Rotation - is establishing grasses and legumes or a mixture of them and maintaining the stand for a definite number of years as part of a conservation cropping system. On marginal cropland, this may be the only solution to reducing erosion to soil loss tolerance. By adding a sod crop in a 3 year rotation, soil loss can be reduced as much as 5 times as compared to continuous corn on the same land (9). Adding sod in a rotation changes the "C" factor in the USLE.

Rotating row crops with sod crops improves soil structure relative to continuous row-cropping. Plowing the sod under helps increase soil organic matter, while the dense root system of a sod crop increases soil porosity (Gerard et al. 1962) (35).

It is well established that surface runoff from a sod crop will generally be considerably less than runoff from a row crop (Bennett, 1939) (36). This effect is due mainly to the increase in soil porosity. The benefit can continue for the first few years of row crop after the sod crop is plowed under. Experiments at the University of Missouri showed that surface runoff and soil losses in corn following sod were only one-third and one-fifth, respectively, of the amounts from continuous corn (Miller and Krusekopf, 1932) (37). Other tests at Missouri showed corn had twice the surface runoff and several times as much soil loss as corn in a corn-wheat-clover rotation (Bennett, 1939) (36). In Georgia on Cecil sandy loam with 7 percent slopes and a three-year rotation of oats-lespedeza, volunteer lespedeza and cotton, the turned-under residues of the lespedeza and oats effectively reduced runoff and erosion during the following cotton year (Hendrickson and Barnett, 1963) (38).

(7) Grassed Waterways - is a natural or constructed depression shaped or graded and established in suitable vegetation for the safe disposal of runoff. Waterways are a prerequisite for implementing a conservation system on most cropland. Although the benefits of grassed waterways are not considered when computing sheet and rill erosion on cropland, they do prevent formation of gullies in depressions and may sufficiently reduce total erosion in a field.

Little research has been done on the effect of grassed waterways for reducing pollutants from agricultural land. Although not conclusive, some research has indicated that grassed waterways were effective in reducing total pollutant load from feed and barnlots (39).

(8) Filter Strips - is a strip or area of vegetation for removing sediment, organic matter, and other pollutants from runoff.

This is a relatively new conservation practice although the concept has been used for many years with contour stripcropping. Since the effect of stripcropping on runoff is minimal, the effect of filter strips on runoff should be minimal.

Filter strips are not considered when computing reduction in sheet and rill erosion on cropland. They are effective in reducing erosion on the strip around the field.

Filter strips need to be graded to a uniform surface and width will depend on slope, soils, and type of pollutants to be removed. Generally, strips 15 feet wide are effective on cropland when slopes are less than 5%. Widths should be increased for steeper slopes (10).

(9) Crop Residue - Using plant residue to protect cultivated fields during critical erosion periods. In North Carolina, most crop residue is from corn and soybeans and protects many fields from harvest until the next planting season. Residue protects the soil from the erosive force of raindrops and wind. Three tons of corn residue per acre can reduce soil loss by 85 percent on moderate length slopes.