Erosion and Crop Production in the Cornbelt

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Man has learned a great deal about erosion and its control. However, soil erosion is considered to be occurring at excessive rates in many areas. Much has been said and written about the problem in the past fifty years---yet the problem persists. Some progress has been made in reducing the loss of soil from crop-producing areas, but many people believe that the progress is inadequate to increase or even maintain future food production needs.

The problem of soil erosion and its subsequent effects on crop production, water quality and sediment deposition is very complex. Technology, economics, politics and social feasibility factors must be considered jointly to define adequate erosion control. Farmers, land owners, soil and water conservation districts, special interest groups and political groups must interact in developing policies on the amount of erosion that can be tolerated. Science needs to provide information on the consequences of various options available.

Erosion Research in the Cornbelt

Considerable research has been conducted in the cornbelt since the early 1900's to determine the effects of various crop and soil management practices on soil losses. The Missouri Experiment Station started runoff and erosion plot studies in 1917. Duley (1924) and Miller and Kuesekopf (1932) reported comparisons of runoff and erosion data from natural precipitation among various cropping systems. The plots used in these studies were designated as a National Historical Landmark in 1965. After the erosion plot studies were started in Missouri, similar studies were conducted in Iowa, Illinois, Indiana, Wisconsin and Minnesota. Most of these investigations were made during the period of the 1940's through the 1960's and show runoff and soil loss data comparisons for various crop management systems under varied soil and natural precipitation conditions. Short-term results (less than ten years and in many cases less than 5 years) have been reported from these studies. Consequently, the cumulative effect of erosion on crop productivity is difficult to evaluate. Ironically, high erosion years frequently coincide with high crop production years.

Technology advances in plant genetics, fertilizer management and pest control in the past few years have masked out the effects of erosion on crop production for some soils.

Erosion - Crop Production Relationships

Spomer and Piest (1981) recently reported that Iowa corn yields increased rapidly in the past 20 years even though soil erosion from unprotected corn fields greatly exceeded soil loss tolerance values. Mechanical scalping of a deep loess soil surface at Clarinda, Iowa (Musgrave and Norton, 1937) and Shelby silt loam at Bethany, Missouri (Smith et al., 1945) showed corn yields were 20 and 40%, respectively, of those from control plots. A nine-year study in Ohio (Borst et al., 1945) showed that corn yields were drastically reduced from severely eroded Muskingum loam (36 inches to bedrock). Field trials in Minnesota and Wisconsin (Hayes et al., 1949) showed that grain yield from severely eroded soils in Minnesota were about two-thirds of those for slightly eroded soils. In Wisconsin, yields from severely eroded land were about three-fourths of those from slightly eroded land.

Unpublished plot study data from a claypan soil at Kingdom City, Missouri, have shown that corn yields have increased despite intensive conventional tillage for the past 37 years (1941-1977). The study has also shown that cumulative soil loss by water erosion among 39 plots for the 37-year period ranged from 0.1 to 1.8 inches. A soybean yield variability study conducted in 1979 and 1980 showed a very low relationship to cumulative 37-year soil loss. According to Jensen (1978), "It seems unlikely that any future advancement in technology will be able to generate a sustained rise in productivity from present high levels." Future erosion-productivity relationships may well be more significant than past data reveals if Jensen's appraisal is correct.

Soil Loss Tolerance

It is generally agreed that soils vary widely in their development, physical and chemical characteristics, production potential and erosion. Early attempts by Zingg (1940) to predict amounts of erosion encouraged efforts to specify amounts of soil erosion that might be tolerated on specific soils (Hays and Clark, 1941, and Smith, 1941). Browning et al. (1947) made a thorough review of soil erosion research in the Midwest and identified maximum average permissible soil loss without decreasing productivity. The prime factor used in determining these values was the loss of productivity per inch of top soil lost. In the 1950's, Bartelli and Boatman proposed a maximum limit of 7 tons/ac/yr for deep soils with favorable subsoils in Illinois and Iowa. The Tama soil was cited as a deep soil on which erosion would have the least effect on crop yields. Thompson (1952) and Van Doren and Bartelli (1956) lowered the tolerance levels to 6 and 4.5 t/ac/yr. Tolerance graded downward to 0.5 and 1.5 for shallower soils in Iowa. A tolerance level of 5 t/ac/yr for Tama and similar deep soil was frequently used between the late 1950's and the mid 1970's when the SCS began to reevaluate the issues (Young, 1978).

Current criteria for soil loss tolerance was discussed by D. E. McCormack et al. (1979). Soil loss tolerance was defined as the maximum rate of annual soil erosion that will permit a high level of productivity to be obtained economically and indefinitely. As pointed out by these authors, the definition implies--but does not directly state--that there should be no loss in the long-term productivity of the soil and that long-term productivity depends on maintaining the thickness of the horizon and a sufficient rooting depth. Rates of topsoil formation of 5 t/ac/yr and development of a favorable rooting zone from weathering of unconsolidated parent materials of 0.5 t/ac/yr were considered as major factors in establishing current levels of soil loss tolerance while maintaining productivity.

Application of Soil Loss Tolerance Levels and Associated Recent Research

Shrader et al. (1963) proposed two general groups into which upland soils in the central and eastern United States could be divided for characterizing the effects of erosion on production. The first group included soils in which texture, permeability, ease of tillage and other characteristics of the subsoil were similar to properties of the soil surface. The deep loess soils of southwestern Iowa were cited as being representative of this group. Application of current technology, principally increased fertilization, has masked out production effects of erosion. Spomer and Piest's (1981) work, cited earlier, supports this theory. Shrader and co-workers (1963) also evaluated the economics for various levels of erosion control. Over- and under-design for erosion control reduced maximum net farm revenue obtainable. The second soil group considered included soils for which the subsoil provides an inferior medium for plant growth as compared to the surface soil. Erosion from these soils also results in increased production costs, but yields are less than those obtained without occurrence of erosion. Consequently, net farm income is lower from eroded than non-eroded phases of these soils. The claypan soils occurring along the southern fringes of the cornbelt and other shallow soils were cited as representative of this soil group. Jamison et al. (1968) described soil and water management problems associated with claypan soils in Missouri. These researchers concluded that the shallow slowly permeable soils were not well suited for row crop production because of water management problem extremes and erosion hazards. It was recommended that these soils were best suited for forage crop production. However, intensity of row cropping and associated tillage has increased on the claypan soils in recent years. The increased use of fertilizers since the 1950's has increased corn yields. Adequate water during the cropping season provided by favorable amounts and distribution of rainfall or the application of supplemental water has produced dramatically high corn yields comparable to the deeper cornbelt soils.

Unpublished data from 37 years (1941-77) of records from the Kingdom City, Mo., claypan plot study has shown average annual soil loss from corn following corn under conventional tillage was only 3.6 t/ac. A single plot cropped continuously to corn 24 years (1954-72) with conventional tillage had an average annual soil loss of 2.7 t/ac. High erosion years in the early 1940's and the late 1960's contributed substantially to these losses. The 37-year average annual losses are well below the soil loss tolerance level of 5 tons/ac/yr. The plot study data indicates that either erosion is not a major problem for the soil-climatic conditions studied or the soil loss tolerance value presently used is too high.

The claypan plot study in Missouri suggests that the water management problem is greater than the erosion problem. Average annual runoff was at least two times greater for the claypan than from the deeper, more permeable soils in the cornbelt. The application of erosion control principles advanced by Shrader et al. (1963) may also be used to evaluate water management.

C. R. Amerman and R. B. Grossman (personal communication) initiated claypan soil profile modification research in 1976 relevant to erosion control and water management issues. These researchers conducted infiltration studies after mechanically modifying the claypan layer with and without treatment of calcium hydroxide. The modified claypan layer that did not receive calcium hydroxide resealed the following summer after treatment as evidenced by low permeability rates from infiltrometer applications at rates of 2½ inches per hour for 2 hours. The calcium hydroxide treated mechanically modified claypan layer maintained high infiltration rates five years after treatment. Although such drastic treatment is not considered feasible within the current economic and sociological climate, this study has demonstrated technological potential for improving soil and water management.

Another exotic area of technology that could well have long-range potential would be the reclamation of sediment deposits by returning such materials to eroded surfaces or applying the materials to shallow

low production soils. Providing sediment catchment basins to field-size areas may have shorter-range potential. Questions regarding plant responses, and effects on subsequent runoff and erosion for distribution of sediment materials need to be answered. To what extent should this type of research be conducted that may not prove to be fruitful for many years or generations?

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