Soil Erosion, Crop Productivity and Cultural Practices

by Mahdi Al-Kaisi

Soil erosion affects not only the site where the erosion takes place, but also off-site where sediment contributes to water quality problems. This publication focuses on the effects of soil erosion on productivity, particularly yield, which occurs at the erosion site. The loss of production due to erosion can be caused by deterioration in soil physical and chemical properties such as infiltration rate, water-holding capacity, loss of nutrients needed for crop production, and loss of soil carbon.

The effects of soil loss on production varies, depending upon the type and depth of the topsoil. Some seriously eroded soils cannot be used for crop production. Many studies have examined the effect of topsoil depth on corn yields in the Corn Belt states. Figure 1 summarizes the relationship between topsoil depth and crop productivity. There is a direct relationship between topsoil depth and yield. The decline in yield with the reduction in topsoil depth can be related to A horizon (topsoil) thickness.

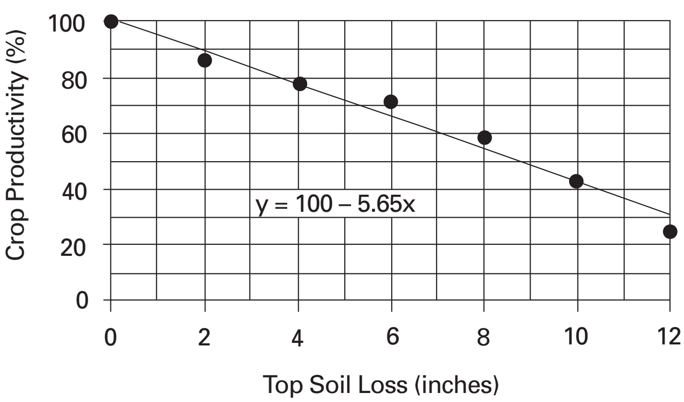

Figure 1. Reduction in crop productivity from loss of topsoil. Data were collected primarily on soils without adequate fertilizer treatment (Stallings 1964).

Relationship between soil A horizon thickness (topsoil) and yield

Infiltration rate and water availability become limited as the topsoil erodes. The subsoil does not absorb the rainfall as rapidly, leading to more surface water runoff and less available water for crop production. A study on erosion and slope effects on productivity, especially yield, was initiated in 10 Iowa counties in 1983 and expanded to 44 counties in 1984. The objective of the study was to determine the effects of slope and erosion and their interaction with other variables such as moisture, fertilizer rates, and slope on crop productivity. The study found a strong relationship between soil A horizon thickness and yield. The decline in yield was especially pronounced in till-derived soil, where the A horizon thickness declined, compared with loess-derived soils. Similarly, there was a strong relationship between yields and slopes for the same soils. This is because till-derived soils have shallower soil depth compared with loess-derived soils and the water-holding capacity, bulk density, and nutrients become a detriment to yield.

The thickness of A horizon had an effect on yield up to a point (Fig. 2). As the A horizon thickness increased from 1.5 inches (mid-range for the severely eroded soils) to 5 inches (mid-range for moderately eroded soils), increase in estimated corn yield was 13 bu. per acre. However, the rate of increase in yield was much lower, especially in loess-derived soils compared with till-derived soils. The change in yield between soil A horizon, 5 inches thick, and soil A horizon, 12.5 inches thick (mid-range for the slightly eroded soils), was 8.9 bu. per acre. The change in soil A horizon thickness plays a significant role in changing the amount of soil moisture that will be stored for the plant use. One study showed that when the rainfall was adequate during the growing season, there was little difference in yield regardless of A horizon thickness. However, in years when rainfall was not adequate, there was an extreme difference in yield. In general, the results show that corn yields were much greater for loess-derived soils compared with till-derived soils having the same A horizon thickness (Fig. 2).

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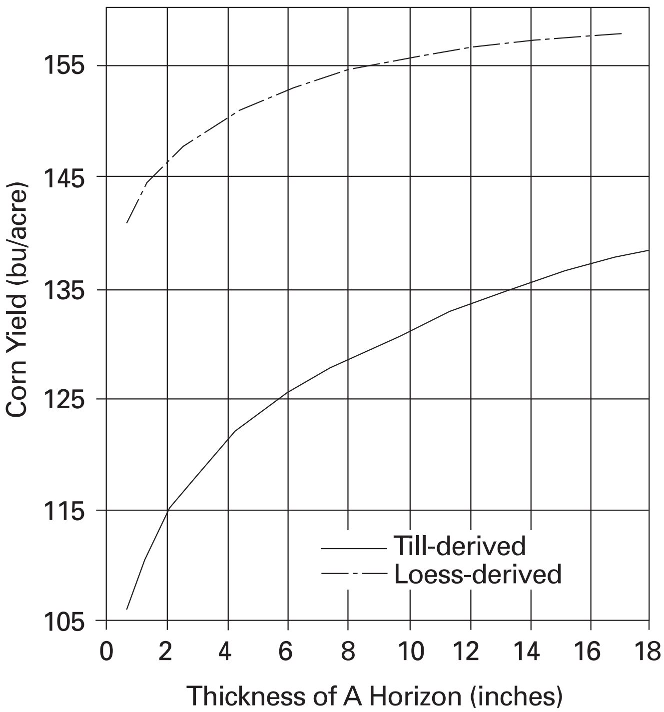

Figure 2. Effect of A horizon thickness on corn yields for loess-derived and till-derived soils (Kazemi et al., 1990).

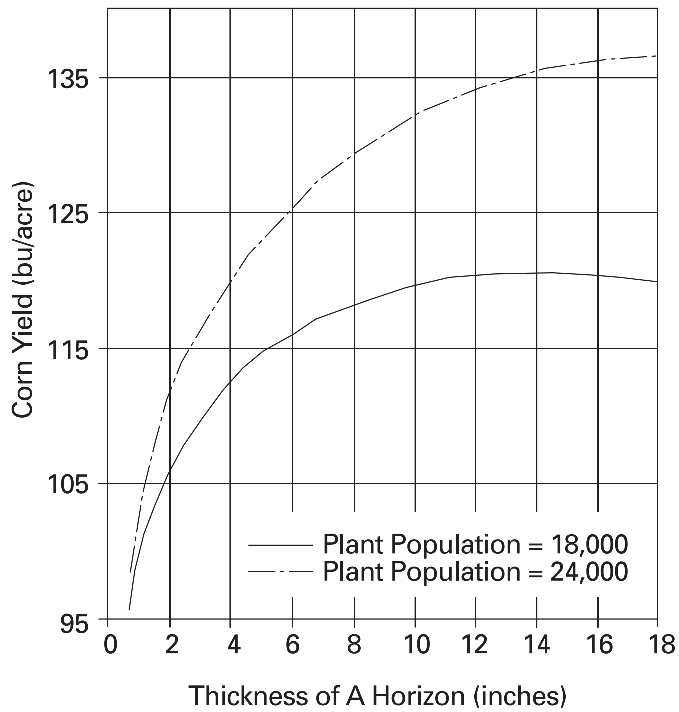

Figure 3. Effect of A horizon thickness on corn yields at populations of 18,000 and 24,000 plants per acre for till-derived soils (Kazemi et al., 1990).

Relationship between cultural management and yield

The relationship between A horizon thickness, corn population, and nitrogen fertilizer rate is summarized in Figures 3–5, respectively. Yield response is greatly affected by the plant population of corn growing on till- or loess-derived soils. Yields increase considerably when a population of 24,000 plants per acre is used compared with 18,000 plants per acre on till-derived soils with different topsoil thickness. In general, the increase in yield was positively correlated with the increase in plant population and topsoil thickness (Figure 3). An increase in plant population can minimize soil erosion loss and subsequently nutrient and water losses due to greater plant canopy density compared with lower density plant populations.

The effects of different N rates on yield for till- (Figure 4) and loess-derived soils (Figure 5) was examined by using nitrogen rates of 80 lb. and 180 lb. N per acre and 100 lb., 150 lb., and 200 lb. N per acre, respectively. The effect of N rate was positive where N partially compensated for yield loss due to erosion and lower water- and nutrient-holding capacities associated with till-derived soils. However, the study by Kazemi and coworkers shows that, even at a rate of 180 lb. N per acre, the yield increase with greater topsoil thickness was not substantial for till-derived soils.

Yield loss due to erosion at an adequate N rate could be attributed to changes in the soil's physical and chemical properties, shallower rooting depth, and perhaps phosphorus (P) and/or potassium (K) deficiencies on the more eroded soils. However, the addition of extra N might solve the yield problem, but create water quality and environmental concerns due to the potential loss of residual soil nutrients to surface runoff and groundwater contamination (Figure 4).

In contrast, the yields of corn grown on loess-derived soils have a much greater response with different N rates than yields of corn grown on till-derived soils (Figure 5). The rate of yield increase is much greater regardless of topsoil thickness compared with till-derived soils. This increase can be attributed to better soil conditions for high water and nutrient availability under loess-derived soils than till-derived soils. The addition of N to soil greatly increases yield. By bringing N up to adequate fertility levels, plant canopy growth is increased, thus providing better cover and reducing soil erosion. However, adding more N and P fertilizers increases the risk of N and P losses with surface water runoff. The amount of N and P loss is highly dependent on soil erosion, which is directly related to the amount of plant residue, tillage practice, slope, placement of fertilizers, timing of fertil-

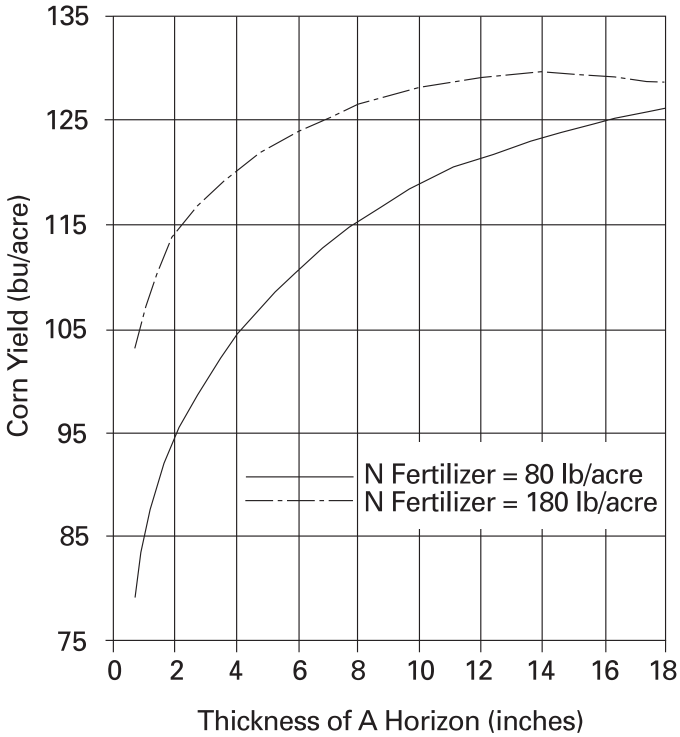

Figure 4. Effect of A horizon thickness on corn yields with two different N rates for till-derived soils (Kazemi et al., 1990).

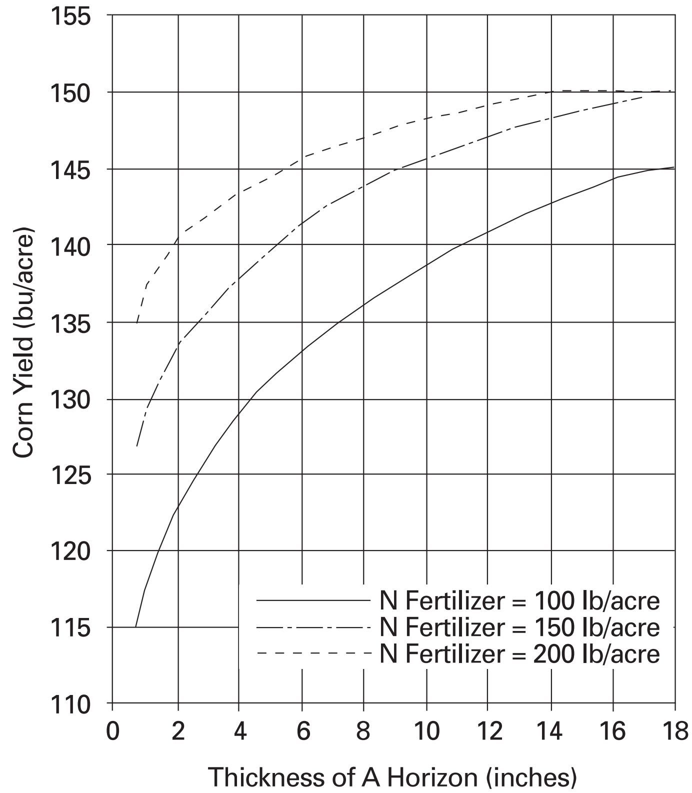

Figure 5. Effect of A horizon thickness on corn yields with three different N rates for loess-derived soils (Kazemi et al., 1990).

izer application, and duration and intensity of rainfall. Therefore, soil testing for N, P, and K is essential to avoid over-application of fertilizers.

Slope is another factor that has significant effects on yield (Fig. 6). The results show that the increase in slope has negative effects on P availability and yield. There was a slight increase in yield as the slope gradient increased at the A horizon that was 11 inches thick. This yield increase was not expected on slopes greater than 9–14%. This could be due to very few observations of the combination effects of A horizon thickness and slopes greater than 14%. It was found that yield was reduced by 0.79 bu./acre for each one percent increase of slope gradient. Therefore, reduction in yield due to changing field slope from 2 to 12.5% was about 8 bu./acre. On the other hand, high moisture availability during July can minimize the negative effects of high moisture stress observed in August on yields.

Soil Management Effects on Yield on Sloped Areas

- Increasing plant population improves yield response.
- Corn yield improves as the topsoil thickness increases.
- Yield of loess-derived soils is much greater than that of till-derived soils.
- Additional N improves yield with an increase in topsoil thickness.
- Corn yield declines significantly when topsoil thickness is less than 11 inches.

Cultural Practices and Soil Erosion

Conservation tillage is an important practice that can effectively reduce soil erosion. Some tillage practices are agronomic and cultural in nature. Others are structural. However, these practices are not mutually exclusive. Erosion is induced by several factors, such as slope and crop rotation. On moderate slopes, the loss reduction of erosion under uphill and downhill planting is approximately 50%. On the other hand, on steep slopes, the hazard of rilling erosion is increased.

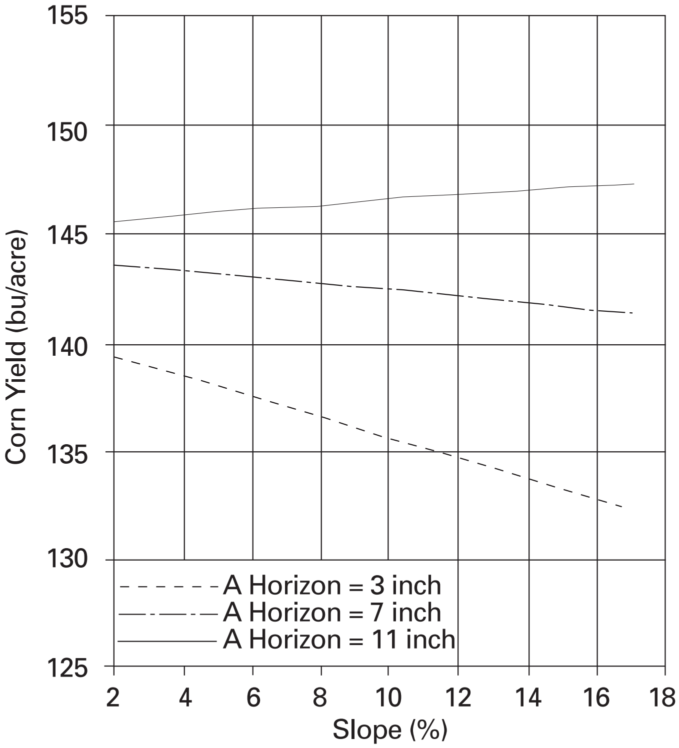

Figure 6. Effects of the slope gradient on corn yields at A horizon thickness of 3, 7, and 11 inches of till-derived soils (Kazemi et al., 1990).

Row spacing is another practice that can be effective in reducing soil erosion on sloping areas. Reducing row spacing can provide dense surface cover and reduce the area of soil surface exposed to water or wind impacts. However, planting, cultivating, and harvesting equipment will dictate the limitation of such a practice. Strip cropping and terracing are other methods to control erosion by dividing the slope into discrete segments. Although there is soil movement within the terrace, the majority of the detached soil stays on the terrace. Grass waterways and buffer strips are another option that can be used to receive excess surface water runoff or drainage water from terrace channels. This practice helps remove sediment from the water before it leaves the field. The contribution of such practices to improving productivity and water quality is significant.

Soil Erosion and Water Quality

- Improving yield on slope areas with additional fertilizer subsequently improves canopy and minimizes soil erosion.
- Conservation tillage and other conservation practices reduce soil erosion and improve water quality.
- Grass waterways and buffer strips are essential to improving water quality.

Conclusion

Erosion is caused by several factors. Slope and crop rotation play a significant role in erosion control. On moderate slopes, uphill and downhill planting is estimated to reduce erosion by approximately 50% less than it is on steep slopes, where the hazard of rill erosion is increased.

Row spacing, when used with other conservation tillage practices, is effective in reducing soil erosion on sloping areas. Reduced row spacing can provide dense surface cover and decrease the area of soil surface exposed to water. Strip cropping, terracing, and grass waterways are other methods to control erosion by dividing the slope into discrete segments. Although there is soil movement within the terrace, the majority of the detached soil stays on the terrace. These practices help remove sediment and some nutrients from the water before it leaves the field. The contribution of such practices to improving productivity and water quality is significant.

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