Effects of Prolonged Erosion on Soil Productivity[1]

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Soil erosion by wind has occurred for many years in the Great Plains. During the infamous "dust bowl", 28 million acres were permanently damaged by loss of top soil. More recently in the 1950's, 46 million acres were permanently damaged. Assessment of the damage of top soil loss on production has been difficult because technological advances such as new crop varieties and fertilization have masked the damage.

One approach for determining the impact of soil loss on productivity has been to artifically remove the top soil from an area that has never been cultivated. Such a study was conducted at the Central Great Plains Research Station from 1958-1962 and the same area is again being used for this purpose after being in grass for 20 years.

At the beginning of the initial cropping period, total nitrogen content of the soil declined from 0.109% with no soil loss to 0.084% with 12 inches of soil loss (Table 1). During the cropping period these values remained nearly constant. In 1982, the total nitrogen content of all soil loss depths was higher than in either 1956 or 1964. The greatest increase occurred where the soil loss was 12 inches and all soil loss depths had similar total nitrogen percentages, except for the no soil loss area. Nitrate-N release during incubation was initially decreased with increased soil loss, but in 1982 there was almost no difference in nitrate-N release between soil loss levels. The analyses made in 1964 showed soil nitrogen levels essentially the same as when the soil loss initially occurred. Nitrate-N was not determined on the samples collected in 1964.

Labile sodium bicarbonate extractable phosphorus initially decreased to only 5.4 lbs/ac as soil loss increased to 12 inches (Table 1). Eight years later, the phosphorus levels of each soil loss depth had increased, but the greatest increases occurred where soil losses had been the greatest. When analyses were made in 1982, phosphorus levels in all soil loss levels were lower than 18 years earlier, but were similar for all soil loss depths. In 1982, the phosphorus level in all soil loss depths was low enough so that a response to phosphorus fertilizer would be expected.

Analyses of the soil for nitrogen and phosphorus shows that soil loss has affected the amount of these nutrients present in the soil. However, 26 years after soil loss the difference in these nutrients between soil loss depths minimal.

Production of winter wheat during the initial cropping period (1958-1962) decreased with increasing loss of top soil (Table 2). The average loss in

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wheat production was 0.1 bu/ac/in of top soil (32 tons) loss up to 9 inches (384 ton). When top soil removal was 12 inches, wheat production decreased 1.2 bu/ac/in of top soil loss between 9 and 12 inches. With the application of 35 lbs/ac of N plus 45 lbs/ac of P per crop the grain yields from even the most severe soil loss area equalled the yield on the no soil loss area without fertilizer. Production in 1986 was higher than that obtained earlier but without fertilizer there was a 0.5 bu/ac decrease in production per inch of soil loss up to 9 inches. A soil loss from 9 to 12 inches resulted in a 1.5 bu/ac loss in production per inch of soil loss. These production losses were similar to those obtained in the earlier cropping period, even though the levels of nitrogen and phosphorus in the soil were similar which was not the case in the earlier cropping period. In 1986, the application of nitrogen and phosphorus resulted in a production increase with each increase in soil loss up to 9 inches, however, with 12 inches of soil loss, the grain yield was only 3.7 bu/ac better than with no fertilization and no soil loss. Similar yield increses were obtained with soil losses up to 9 inches when nitrogen and phosphorus were applied in the earlier cropping period.

The plot area is level in all directions and soil water measurements have shown that soil loss is not detrimental to soil water storage. Data (not presented) in the early cropping period and for the 1986 crop has consistently shown that the no soil loss area with the lowest available soil water at seeding. For the 1986 crop, soil water at planting in the 12-inch soil loss area was equal to or better than the soil water in all other soil loss depths. This leads to the conclusion that factors, other than the nutrients, nitrogen and phosphorus and water are limiting production in this area. The results to date indicate that if erosion persists until over 9 inches of top soil are lost, productivity will decrease sharply and the technological inputs to restore soil productivity will be extensive.

Table 1. Nitrogen and phosphorus contents in the surface 2 inches of soil with different amounts of soil loss and at different times after soil loss. Akron, Colorado.

Soil loss depth	Sampling time		
in.	1956	1964	1982
		Total nitrogen (%)	
0	0.109 d*	0.107 d	0.125 b
3	0.097 c	0.097 c	0.100 a
6	0.094 bc	0.093 bc	0.105 a
9	0.087 ab	0.084 ab	0.105 a
12	0.084 a	0.080 a	0.108 a
		Phosphorus (lbs/ac)	
0	24.1 b	32.1 bc	13.6 a
3	17.9 b	28.6 b	12.2 a
6	9.8 ab	26.8 b	11.2 a
9	7.1 a	22.3 a	10.8 a
12	5.4 a	21.4 a	14.2 a
		Nitrate-N (lbs/ac)**	
0	56.3 c	-	64.6 b
3	55.4 c	-	57.1 ab
6	52.7 bc	-	38.9 ab
9	48.2 b	-	58.2 ab
12	42.9 a	-	55.1 a

* Values within each column accompanied by different letters are significantly different at the 95% level of probability.

** Nitrate accumulation during 30 days incubation at 35°C.

Table 2. Winter wheat production as affected by soil loss and nitrogen fertilizer in 1958-1962 and 1986.

Soil loss depth	Cropping Period			
	1958-62		1986	
	0	N+P*	0	N+P**
in.	bu/ac			
0	23	22	33	40
3	23	24	30	43
6	22	21	30	44
9	22	26	29	50
12	18	23	24	37
LSD	2	2	3	3

* Fertilizer rate was 35 + 45, N+P/ac, respectively on each crop applied at planting.

** Fertilizer rate was 80 + 22, N+P/ac, respectively on the crop applied at planting.